



**TOTAL IONIZING DOSE TEST REPORT (REV1)**

**RT4G150 – Lot: KRMLM**

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## I. SUMMARY TABLE

Parameter	Tolerance
1. Gross Functionality	Passed 125krad(SiO <sub>2</sub> )
2. Power Supply Current	Passed 125krad(SiO <sub>2</sub> )
3. Input Threshold (VTIL/VIH)	Passed 125krad(SiO <sub>2</sub> )
4. Output Drive (VOL/VOH)	Passed 125krad(SiO <sub>2</sub> )
5. Propagation Delay	Passed 125krad(SiO <sub>2</sub> ) for 10% degradation criterion
6. Transition Time	Passed 125krad(SiO <sub>2</sub> )

## II. TOTAL IONIZING DOSE (TID) TESTING

This testing is designed on the basis of an extensive database of TID testing for Radiation-Tolerant FPGAs including flash-based FPGAs. Microsemi TID reports can be found at <http://www.microsemi.com/products/fpga-soc/radtolerant-fpgas/military-aerospace-radiation-reliability-data#tid-reports>

Electrical parameters are measured pre-irradiation and post-irradiation using the burn in design and the ATE test program. The report summarizes sample pins. Two factors make sampling appropriate: first, the tolerance is determined by current and propagation delays which are global parameters; second the total dose effect is uniformly distributed across the chip.

### A. Device-Under-Test (DUT) and Irradiation Parameters

Table 1 lists the DUT and irradiation parameters. During irradiation each input and most of the output is grounded.

*Table. 1. DUT and Irradiation Parameters*

Part Number	RT4G150
Package	LG1657
Foundry	United Microelectronics Corp.
Technology	65 nm
DUT Design	Burn in design with inverter string
Die Lot Number	KRMLM
Quantity Tested	3
Serial Number	4594, 4601,4649
Radiation Facility	Defense Microelectronics Activity
Radiation Source	Co-60
Dose Rate	5 krad (SiO <sub>2</sub> )/min
Irradiation Temperature	Room
Irradiation and Measurement Bias	Static at 1.2V/2.5V/3.3V/3.3V
IO Configuration	Single ended Differential Pair

## B. Test Method

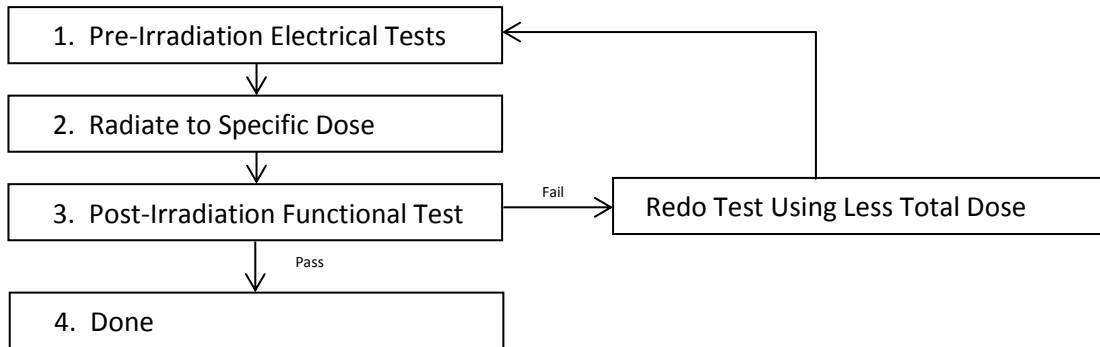


Fig. 1. Parametric test flow chart

The test method generally follows the guidelines in the military standard TM1019. Figure 1 shows the flow chart describing the steps for the functional and parametric tests.

## C. Design and Parametric Measurements

RTG4 FPGA devices have different types of I/Os, such as MSIO and MSIOD, double data rate I/Os (DDRIO), and dedicated I/Os based on functional usage. For more information on I/O naming conventions and I/O description, refer to the RTG4 FPGA Pin Description. All I/Os are tested pre and post-irradiation.

Fabric functionality coverage performed by the burn in design is summarized in table 2 below. In addition to the fabric coverage the supplemental test of propagation delay is also used to determine DUT functionality. These tests are performed pre and post-irradiation and recorded as a pass/fail. Refer to appendix A for a graphical representation of fabric functional coverage blocks used to perform the functional tests.

Table. 2. Fabric Functional Coverage

<b>Block</b>	<b>Coverage</b>
Combo Block	combinatorial macros available in the RTG4 library
Register Block	sequential macros available in the RTG4 library
UPROM	Maximum output toggle rate(checker board) compared to reference
Embedded SRAM Blocks	full toggle coverage on 209 fabric LSRAM & 210 uRAM blocks using dual port/ two port configurations (x18 width)
Shift Register Block	core utilization
I/O Block	I/O utilization
Math Block	full toggle coverage on 462 fabric math blocks with maximum width configuration



The core power supply current  $I_{DD}$ , the I/Os power supply currents ( $I_{DDI\_2.5}/I_{DDI\_3.3}$ ) and the charge pump/PLL power supply current ( $I_{PP\_PLL}$ ) are also monitored during irradiation in real time.

The input logic threshold ( $V_{IL}/V_{IH}$ ) is measured on all single-ended inputs as well as all differential inputs, and is reported as a pass or fail, as part of the ATE test program. The output-drive voltage ( $V_{OL}/V_{OH}$ ) is also measured on all pins on the MSIO MSIOD and DDRIO. This report contains the output-drive voltage measurements on selected IO pins used in the burn in design are reported at the LVTTTL and LVCMOS 2.5V standard at different sourcing and sinking currents.

A 2000 stage inverter string is used to measure propagation delay. The propagation delay is defined as the time delay from the triggering edge at the Clock input to the switching edge at the output. The propagation delay is monitored real time during irradiation and the time difference between positive switching edges of the clock and output are reported. Additionally, the transition characteristics (rise and fall) at the output of the inverter chain are measured pre and post-irradiation. Oscilloscope screen captures are shown in section III. F.

### III. TEST RESULTS

#### A. Functionality

Every DUT passed the pre-irradiation and post-irradiation functional tests mentioned in section IIc.

#### B. Power Supply Current

The core power supply current ( $I_{DD}$ ) is 1.2 V, the I/O bank power supply currents ( $I_{DDI}$ ) are 2.5 V ( $I_{DDI\_2.5}$ ) and 3.3 V ( $I_{DDI\_3.3}$ ). The charge pump and PLL power supply current ( $I_{PP\_PLL}$ ) is 3.3 V. Figures 2-12 illustrate the plot of in-flux standby  $I_{DD}$ ,  $I_{DDI\_2.5}$ ,  $I_{DDI\_3.3}$  and  $I_{PP\_PLL}$  versus total dose for every DUT. Tables 3-6 summarize the pre-irradiation and post-irradiation total current (static & dynamic)  $I_{DD}$ ,  $I_{DDI\_2.5}$ ,  $I_{DDI\_3.3}$  and  $I_{PP\_PLL}$ . In each case the current measured pre and post irradiation is minimal.

Note that the delta in the current measurements for DUT 4601 is relatively lower in comparison to the other 2 DUTs. This is because the current was not monitored during running time and recorded values are taken after beam stopped. These readings are taken within an hour which is within the testing spec.

Table 3. Pre-irradiation and Post irradiation  $I_{DD}$

DUT	Total Dose	Pre-Irradiation (A)	Post-irradiation (A)	Increase (%)
4601	125 krad	0.452	0.470	3.98
4594	125 krad	0.347	0.371	6.73
4649	125 krad	0.410	0.431	5.06

Table. 4. Pre-irradiation and Post irradiation  $I_{DDI\_2.5}$

DUT	Total Dose	Pre-Irradiation (A)	Post-irradiation (A)	Increase (%)
4601	125 krad	0.0114	0.0138	21.05
4594	125 krad	0.0112	0.0140	24.70
4649	125 krad	0.0112	0.0139	24.60

Table. 5. Pre-irradiation and Post irradiation  $I_{DDI\_3.3}$

DUT	Total Dose	Pre-Irradiation (A)	Post-irradiation (A)	Increase (%)
4601	125 krad	0.0325	0.0352	8.3
4594	125 krad	0.0383	0.0449	17.27
4649	125 krad	0.0379	0.0448	18.32

Table. 6. Pre-irradiation and Post irradiation  $I_{PP\_PLL}$

DUT	Total Dose	Pre-Irradiation (A)	Post-irradiation (A)	Increase (%)
4601	125 krad	0.0159	0.0161	1.26
4594	125 krad	0.0162	0.0164	1.10
4649	125 krad	0.0159	0.0164	2.70

Following figures (2-9) show the in-beam monitoring of the currents mentioned above as a function of TID for the available DUTs.

## DUT 4594

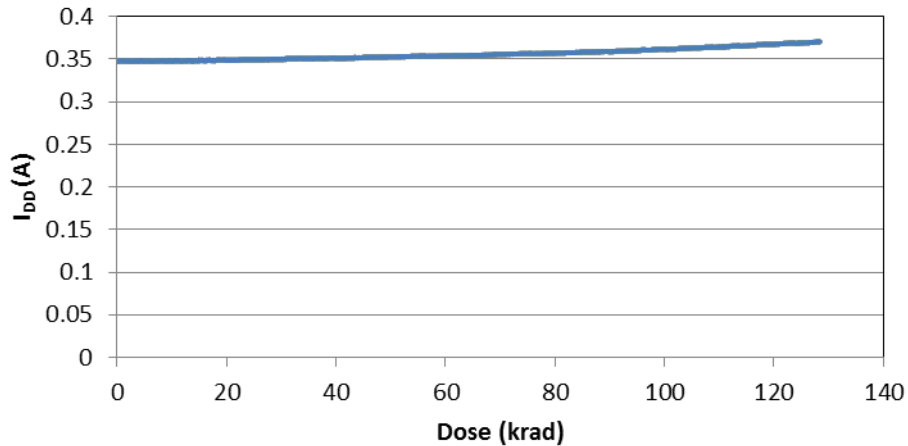


Fig. 2. DUT 4594 core power supply current ( $I_{DD}$ ) versus TID

### DUT 4649

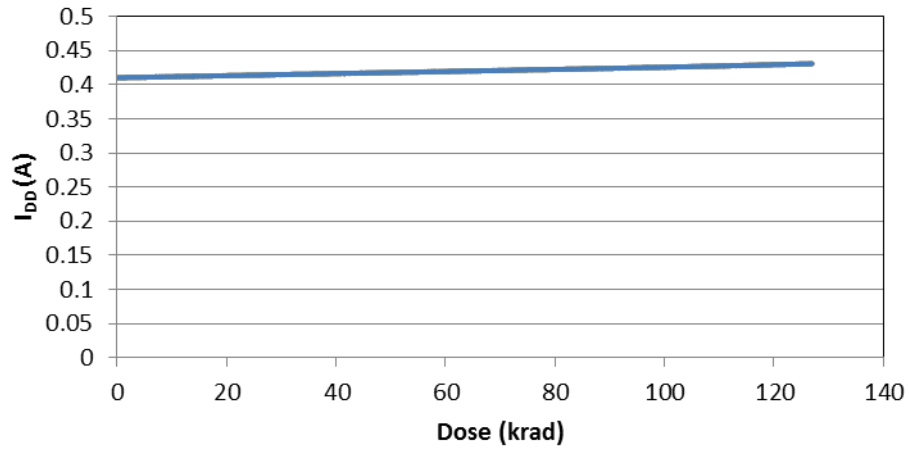


Fig. 3. DUT 4649 core power supply current ( $I_{DD}$ ) versus TID

### DUT 4594

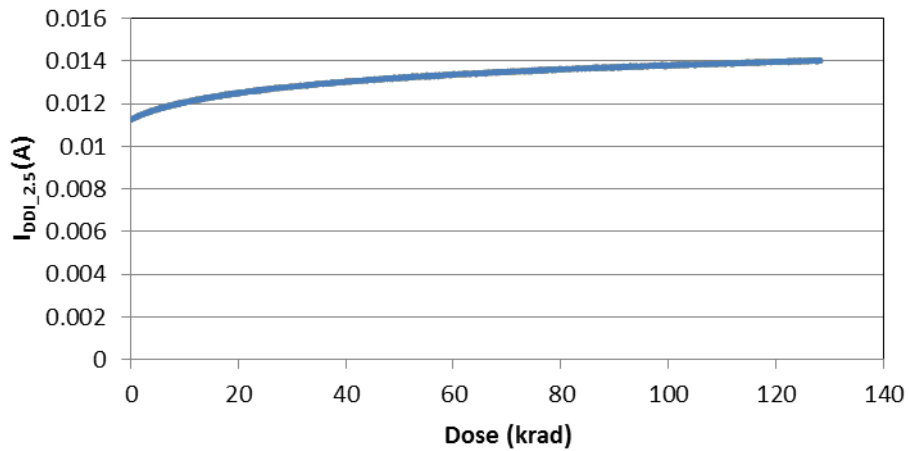


Fig. 4. DUT 4594 I/O bank 2.5V power supply current ( $I_{DD1\_2.5}$ ) versus TID

### DUT 4649

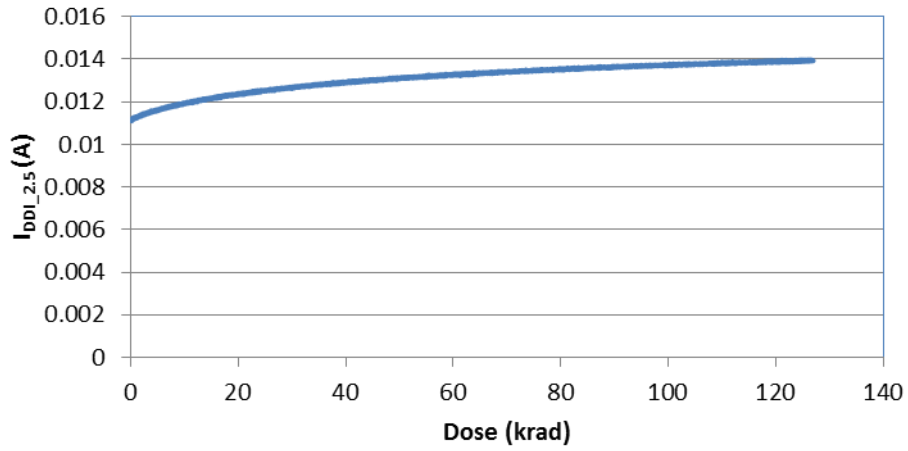


Fig. 5. DUT 4649 I/O bank 2.5V power supply current ( $I_{DDI\_2.5}$ ) versus TID

### DUT 4594

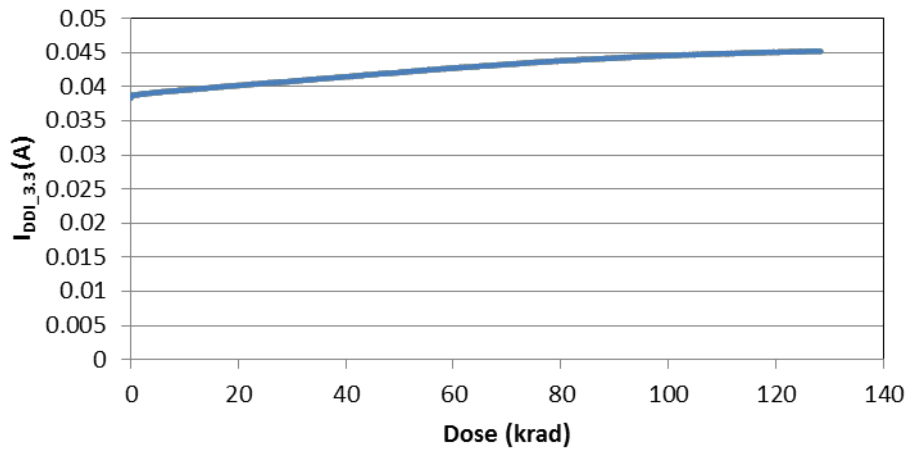


Fig. 6. DUT 4594 I/O bank 3.3V power supply current ( $I_{DDI\_3.3}$ ) versus TID

### DUT 4649

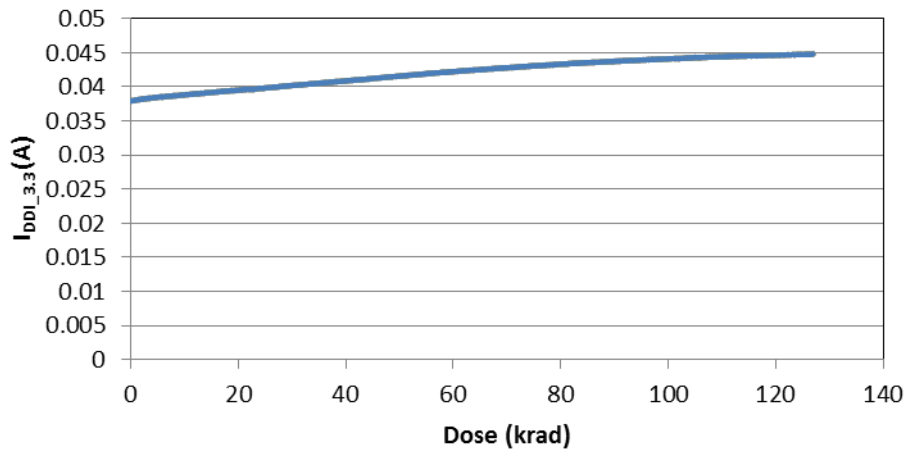


Fig. 7. DUT 4649 I/O bank 3.3V power supply current ( $I_{DDI\_3.3}$ ) versus TID

### DUT 4594

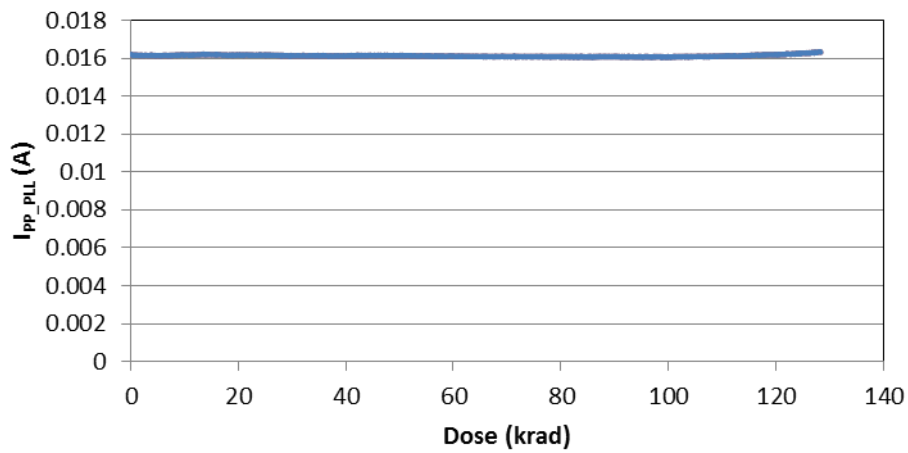


Fig. 8. DUT 4594 charge pump and PLL power supply current ( $I_{PP\_PLL}$ ) versus TID



## DUT 4649

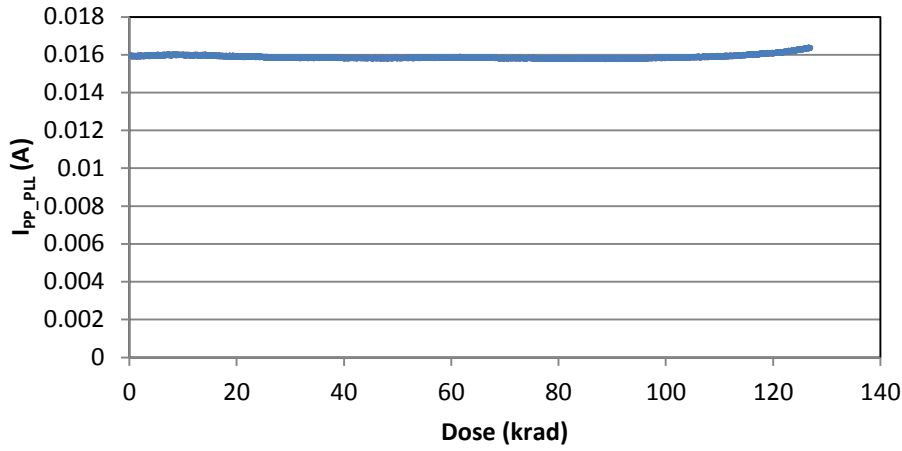


Fig. 9. DUT 4649 charge pump and PLL power supply current ( $I_{PP\_PLL}$ ) versus TID

### C. Single-Ended Input Logic Threshold (VIL/VIH)

The input switching threshold, or trip point, is defined as the applied input voltage at which the output of the design starts to switch. VIH is the input trip point when the input is going high to low and VIL is the input trip point when the input is going low to high. The input logic threshold (VIL/VIH) is measured on all single-ended inputs as well as all differential input and recorded as pass or fail. All I/Os are tested at their respective I/O standards and are compliant to the JEDEC specs. Refer to [http://www.microsemi.com/document-portal/doc\\_view/135193-ds0131-rtg4-fpga-datasheet](http://www.microsemi.com/document-portal/doc_view/135193-ds0131-rtg4-fpga-datasheet) for more information.

The 3 DUTs tested passed with respect to the testing specification pre and post-irradiation. This pass/fail is determined as part of the ATE test program used to perform pre and post-irradiation electrical parametric measurements.

Table 7. VIH Summary

DUT	Pre Irradiation	Post Irradiation
4601	Passed	Passed
4649	Passed	Passed
4594	Passed	Passed

Table 8. VIL Summary

DUT	Pre Irradiation	Post Irradiation
4601	Passed	Passed
4649	Passed	Passed
4594	Passed	Passed



#### D. Output-Drive Voltage (VOL/VOH)

The pre-irradiation and post-irradiation output-drive voltages (VOL/VOH) are performed on all available IOs. The measurements performed pre and post irradiation are within the specification limits; in each case, the radiation-induced degradation is within 10%. For the purpose of this report, the measurements presented below are sampled on several pins used in the burn in design. The respective specs for the data provided are also listed in tables 9 through 12. The testing specs comply with the JEDEC spec as aforementioned.

Table 9. Testing Specs LVCMOS 25 VOH

Forcing Current	Spec
2mA	1.9750 V to 2.3750 V
4mA	1.9750 V to 2.3750 V
6mA	1.9750 V to 2.3750 V
8mA	1.9750 V to 2.3750 V
12mA	1.9750 V to 2.3750 V
14mA	1.9750 V to 2.3750 V

WTable 10. Testing Specs LVCMOS 25 VOL

Forcing Current	Spec
2mA	0.0000 mV to 400.0000 mV
4mA	0.0000 mV to 400.0000 mV
6mA	0.0000 mV to 400.0000 mV
8mA	0.0000 mV to 400.0000 mV
12mA	0.0000 mV to 400.0000 mV
14mA	0.0000 mV to 400.0000 mV

Table 11. Testing Specs LVTTTL VOH

Forcing Current	Spec
2mA	2.4 V to 3.1350 V
4mA	2.4 V to 3.1350 V
8mA	2.4 V to 3.1350 V
12mA	2.4 V to 3.1350 V
16mA	2.4 V to 3.1350 V

Table 12. Testing Specs LVTTTL VOL

Forcing Current	Spec
2mA	0.0000 mV to 400.0000 mV
4mA	0.0000 mV to 400.0000 mV
8mA	0.0000 mV to 400.0000 mV
12mA	0.0000 mV to 400.0000 mV
16mA	0.0000 mV to 400.0000 mV



Table 13. LVCMOS 25 VOH – DUT 4601

Pin Name	Pin #	2mA		4mA		6mA		8mA		12mA		14mA	
		Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad
BIST	A10	2.1309	2.1313	2.2009	2.2009	2.1723	2.1722	2.1514	2.1514	2.1198	2.1198	2.1067	2.1066
CLK	A12	2.1330	2.1333	2.2024	2.2025	2.1736	2.1736	2.1520	2.1523	2.1199	2.1199	2.1063	2.1062
TOGGLE	A13	2.1338	2.1340	2.2037	2.2040	2.1752	2.1754	2.1545	2.1544	2.1233	2.1232	2.1102	2.1100
RESETr	A15	2.1328	2.1330	2.2031	2.2030	2.1746	2.1745	2.1539	2.1539	2.1230	2.1227	2.1100	2.1096
BURNIN_SERDES	A18	2.1336	2.1339	2.2041	2.2043	2.1762	2.1765	2.1562	2.1562	2.1258	2.1258	2.1133	2.1132
OEa	A22	2.1326	2.1326	2.2026	2.2027	2.1740	2.1741	2.1532	2.1534	2.1213	2.1215	2.1082	2.1084
OEb	A23	2.1337	2.1341	2.2041	2.2040	2.1760	2.1763	2.1560	2.1558	2.1259	2.1255	2.1130	2.1127
SETn	A24	2.1329	2.1333	2.2028	2.2029	2.1739	2.1740	2.1531	2.1530	2.1213	2.1211	2.1080	2.1077
BURNIN	A25	2.1335	2.1339	2.2038	2.2038	2.1755	2.1754	2.1551	2.1550	2.1241	2.1240	2.1111	2.1108
TID_BUF_IN	A32	2.1314	2.1312	2.2002	2.2000	2.1707	2.1705	2.1492	2.1485	2.1160	2.1156	2.1018	2.1013
TID_BUF_OUT	A33	2.1310	2.1314	2.2010	2.2011	2.1720	2.1728	2.1509	2.1517	2.1192	2.1203	2.1060	2.1068
EPCSRST_N_0	B31	2.1315	2.1321	2.2008	2.2013	2.1717	2.1724	2.1505	2.1512	2.1179	2.1191	2.1042	2.1056
EPCSRST_N_1	B32	2.1318	2.1321	2.2019	2.2021	2.1733	2.1735	2.1528	2.1530	2.1216	2.1216	2.1085	2.1088
EPCSRST_N_2	B34	2.1304	2.1305	2.2001	2.2002	2.1709	2.1715	2.1499	2.1501	2.1174	2.1180	2.1039	2.1047
EPCSRST_N_3	B35	2.1318	2.1323	2.2020	2.2025	2.1735	2.1741	2.1530	2.1535	2.1222	2.1228	2.1094	2.1098
EPCSRST_N_4	B36	2.1299	2.1302	2.1992	2.1998	2.1700	2.1706	2.1484	2.1486	2.1153	2.1158	2.1016	2.1022
EPCSRST_N_5	B37	2.1309	2.1311	2.2011	2.2013	2.1726	2.1729	2.1517	2.1521	2.1202	2.1206	2.1074	2.1077
SELBLK_0	B5	2.1304	2.1308	2.1998	2.2000	2.1708	2.1711	2.1494	2.1496	2.1170	2.1173	2.1033	2.1036
SELBLK_1	B6	2.1308	2.1313	2.2010	2.2013	2.1726	2.1731	2.1520	2.1523	2.1210	2.1216	2.1082	2.1086
SELBLK_2	C6	2.1307	2.1312	2.2013	2.2016	2.1734	2.1736	2.1535	2.1532	2.1233	2.1233	2.1105	2.1108
SELBLK_3	D7	2.1309	2.1312	2.2022	2.2024	2.1741	2.1746	2.1542	2.1543	2.1242	2.1247	2.1120	2.1122
MONITOR	K23	2.1336	2.1340	2.2039	2.2043	2.1757	2.1760	2.1547	2.1552	2.1243	2.1250	2.1112	2.1121
PLL_MON	L20	2.1334	2.1339	2.2057	2.2061	2.1788	2.1791	2.1603	2.1603	2.1319	2.1323	2.1203	2.1207
TOGGLE_MON	L22	2.1340	2.1346	2.2051	2.2057	2.1777	2.1783	2.1583	2.1591	2.1292	2.1304	2.1175	2.1184



Table 14. LVCMOS 25 VOH – DUT 4649

Pin Name	Pin #	2mA		4mA		6mA		8mA		12mA		14mA	
		Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad
BIST	A10	2.1316	2.1315	2.2011	2.2011	2.1728	2.1723	2.1519	2.1516	2.1208	2.1200	2.1077	2.1067
CLK	A12	2.1340	2.1341	2.2033	2.2031	2.1746	2.1740	2.1534	2.1525	2.1211	2.1206	2.1078	2.1069
TOGGLE	A13	2.1345	2.1345	2.2039	2.2039	2.1758	2.1755	2.1549	2.1544	2.1241	2.1233	2.1113	2.1099
RESETn	A15	2.1345	2.1343	2.2041	2.2038	2.1757	2.1754	2.1552	2.1546	2.1242	2.1234	2.1113	2.1104
BURNIN_SERDES	A18	2.1353	2.1348	2.2049	2.2048	2.1769	2.1767	2.1568	2.1563	2.1266	2.1260	2.1142	2.1132
OEa	A22	2.1342	2.1341	2.2035	2.2033	2.1751	2.1749	2.1539	2.1536	2.1224	2.1217	2.1093	2.1084
OEb	A23	2.1349	2.1352	2.2047	2.2049	2.1767	2.1765	2.1568	2.1563	2.1265	2.1257	2.1137	2.1131
SETn	A24	2.1345	2.1343	2.2035	2.2034	2.1749	2.1746	2.1541	2.1535	2.1222	2.1215	2.1088	2.1081
BURNIN	A25	2.1350	2.1347	2.2046	2.2043	2.1762	2.1760	2.1559	2.1552	2.1248	2.1244	2.1119	2.1111
TID_BUF_IN	A32	2.1316	2.1315	2.2003	2.2000	2.1712	2.1704	2.1495	2.1487	2.1165	2.1153	2.1025	2.1012
TID_BUF_OUT	A33	2.1312	2.1313	2.2014	2.2013	2.1726	2.1725	2.1516	2.1516	2.1198	2.1200	2.1065	2.1067
EPCSRST_N_0	B31	2.1324	2.1327	2.2014	2.2014	2.1724	2.1726	2.1511	2.1515	2.1188	2.1193	2.1053	2.1057
EPCSRST_N_1	B32	2.1322	2.1322	2.2021	2.2022	2.1740	2.1740	2.1531	2.1531	2.1221	2.1220	2.1092	2.1090
EPCSRST_N_2	B34	2.1309	2.1308	2.2003	2.2007	2.1715	2.1718	2.1500	2.1501	2.1178	2.1181	2.1040	2.1044
EPCSRST_N_3	B35	2.1321	2.1322	2.2024	2.2022	2.1741	2.1742	2.1536	2.1536	2.1228	2.1230	2.1100	2.1100
EPCSRST_N_4	B36	2.1307	2.1309	2.1993	2.1994	2.1699	2.1701	2.1481	2.1480	2.1146	2.1147	2.1002	2.1004
EPCSRST_N_5	B37	2.1314	2.1313	2.2008	2.2010	2.1722	2.1723	2.1513	2.1512	2.1196	2.1192	2.1061	2.1061
SELBLK_0	B5	2.1302	2.1299	2.1997	2.1995	2.1705	2.1705	2.1491	2.1487	2.1164	2.1165	2.1027	2.1025
SELBLK_1	B6	2.1308	2.1305	2.2008	2.2010	2.1724	2.1724	2.1517	2.1514	2.1207	2.1207	2.1077	2.1076
SELBLK_2	C6	2.1311	2.1308	2.2015	2.2011	2.1735	2.1733	2.1537	2.1531	2.1234	2.1225	2.1108	2.1098
SELBLK_3	D7	2.1312	2.1312	2.2021	2.2020	2.1740	2.1739	2.1540	2.1538	2.1241	2.1237	2.1118	2.1115
MONITOR	K23	2.1344	2.1343	2.2047	2.2048	2.1764	2.1766	2.1559	2.1556	2.1248	2.1251	2.1122	2.1124
PLL_MON	L20	2.1351	2.1348	2.2066	2.2064	2.1798	2.1798	2.1611	2.1612	2.1327	2.1327	2.1211	2.1210
TOGGLE_MON	L22	2.1346	2.1349	2.2054	2.2059	2.1780	2.1785	2.1586	2.1593	2.1295	2.1298	2.1172	2.1180



Table 15. LVCMOS 25 VOH – 4594

Pin Name	Pin #	2mA		4mA		6mA		8mA		12mA		14mA	
		Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad
BIST	A10	2.1297	2.1304	2.1997	2.2000	2.1710	2.1715	2.1499	2.1500	2.1181	2.1182	2.1050	2.1048
CLK	A12	2.1321	2.1323	2.2019	2.2020	2.1728	2.1730	2.1512	2.1513	2.1189	2.1186	2.1049	2.1048
TOGGLE	A13	2.1327	2.1331	2.2029	2.2030	2.1742	2.1745	2.1530	2.1535	2.1217	2.1220	2.1085	2.1087
RESETr	A15	2.1326	2.1328	2.2028	2.2028	2.1743	2.1743	2.1536	2.1535	2.1223	2.1221	2.1092	2.1093
BURNIN_SERDES	A18	2.1334	2.1339	2.2036	2.2040	2.1756	2.1760	2.1555	2.1554	2.1249	2.1249	2.1120	2.1122
OEa	A22	2.1327	2.1334	2.2026	2.2028	2.1738	2.1741	2.1528	2.1529	2.1211	2.1210	2.1076	2.1078
OEb	A23	2.1329	2.1336	2.2036	2.2038	2.1757	2.1758	2.1553	2.1558	2.1251	2.1251	2.1123	2.1123
SETn	A24	2.1330	2.1332	2.2025	2.2026	2.1736	2.1738	2.1525	2.1526	2.1202	2.1204	2.1072	2.1068
BURNIN	A25	2.1329	2.1335	2.2031	2.2032	2.1747	2.1750	2.1539	2.1543	2.1227	2.1229	2.1096	2.1100
TID_BUF_IN	A32	2.1298	2.1300	2.1992	2.1991	2.1697	2.1696	2.1479	2.1475	2.1145	2.1138	2.1004	2.0997
TID_BUF_OUT	A33	2.1293	2.1300	2.1995	2.2005	2.1706	2.1716	2.1490	2.1501	2.1167	2.1187	2.1032	2.1052
EPCSRST_N_0	B31	2.1305	2.1314	2.2001	2.2008	2.1709	2.1717	2.1491	2.1502	2.1166	2.1181	2.1028	2.1042
EPCSRST_N_1	B32	2.1314	2.1317	2.2013	2.2017	2.1727	2.1730	2.1518	2.1519	2.1200	2.1208	2.1069	2.1078
EPCSRST_N_2	B34	2.1298	2.1305	2.1996	2.1999	2.1704	2.1712	2.1488	2.1494	2.1165	2.1170	2.1030	2.1036
EPCSRST_N_3	B35	2.1302	2.1310	2.2011	2.2013	2.1726	2.1731	2.1518	2.1523	2.1209	2.1215	2.1081	2.1087
EPCSRST_N_4	B36	2.1297	2.1303	2.1988	2.1995	2.1692	2.1699	2.1472	2.1481	2.1141	2.1151	2.1001	2.1016
EPCSRST_N_5	B37	2.1299	2.1305	2.2004	2.2009	2.1720	2.1726	2.1509	2.1515	2.1191	2.1200	2.1064	2.1072
SELBLK_0	B5	2.1279	2.1284	2.1982	2.1989	2.1693	2.1698	2.1480	2.1483	2.1157	2.1163	2.1021	2.1027
SELBLK_1	B6	2.1287	2.1291	2.1995	2.2004	2.1713	2.1719	2.1505	2.1513	2.1195	2.1204	2.1068	2.1077
SELBLK_2	C6	2.1289	2.1294	2.2003	2.2007	2.1724	2.1728	2.1521	2.1525	2.1219	2.1224	2.1096	2.1101
SELBLK_3	D7	2.1296	2.1300	2.2008	2.2013	2.1730	2.1733	2.1528	2.1531	2.1227	2.1232	2.1104	2.1111
MONITOR	K23	2.1321	2.1325	2.2031	2.2037	2.1749	2.1754	2.1540	2.1543	2.1234	2.1240	2.1102	2.1111
PLL_MON	L20	2.1335	2.1342	2.2055	2.2058	2.1786	2.1788	2.1598	2.1599	2.1310	2.1313	2.1196	2.1196
TOGGLE_MON	L22	2.1330	2.1339	2.2041	2.2050	2.1765	2.1778	2.1571	2.1582	2.1275	2.1293	2.1152	2.1171



Table 16. LVCMOS 25 VOL - 4601

Pin Name	Pin #	2mA		4mA		6mA		8mA		12mA		14mA	
		Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad
BIST	A10	236.9349	234.6492	168.0736	166.9182	195.8919	194.5481	216.1371	214.7179	246.9821	245.5253	260.1064	258.8504
CLK	A12	237.7764	235.5032	169.1411	167.8224	197.3864	195.9045	217.9958	216.3757	249.5191	248.0748	263.1582	261.8144
TOGGLE	A13	236.7465	234.4231	167.6592	166.5037	195.4272	193.9704	215.5217	213.9644	246.1156	244.6713	259.2272	257.8080
RESEt <sub>n</sub>	A15	237.6660	235.6819	168.1972	167.1172	196.0249	194.8319	216.1925	215.0121	246.5443	245.3764	259.4786	258.2982
BURNIN_SERDES	A18	236.3349	234.2755	166.8786	165.7485	194.0408	192.7223	213.7688	212.3122	243.5304	242.1993	256.1885	254.8449
OEa	A22	238.1432	236.0335	168.7121	167.4312	196.5021	195.1459	216.7827	215.2758	247.7498	246.2429	260.9604	259.4284
OEb	A23	236.6488	234.4638	167.1549	165.9117	194.4301	193.1743	214.1707	212.9526	243.8318	242.5258	256.3643	255.1462
SET <sub>n</sub>	A24	237.2516	235.0666	168.4986	167.2303	196.5398	195.1961	217.1092	215.7027	248.2647	246.8959	261.5506	260.2698
BURNIN	A25	236.3851	234.2755	167.3558	166.1377	194.9450	193.6264	215.1000	213.6181	245.3764	243.9825	258.3610	257.0676
TID_BUF_IN	A32	237.7512	236.0306	169.7314	168.6513	198.1777	197.2860	219.1387	218.1466	251.5536	250.8503	265.4565	264.8034
TID_BUF_OUT	A33	237.5001	234.7371	168.7016	167.0061	196.7083	194.7616	216.8907	214.6677	247.8864	245.5253	261.0860	258.6495
EPCSRST_N_0	B31	236.9098	234.5236	168.8648	167.2070	197.0725	195.1509	217.6819	215.2454	249.3684	246.8063	263.0326	260.2319
EPCSRST_N_1	B32	235.9876	233.6008	167.4751	166.1812	194.9856	193.4908	215.2102	213.2255	245.7984	243.7885	258.7874	256.9534
EPCSRST_N_2	B34	237.7086	235.6861	169.5101	168.0153	197.6990	195.9277	218.2125	216.0142	249.7554	247.5822	263.2594	260.8601
EPCSRST_N_3	B35	236.8292	234.5179	167.8771	166.4450	195.4755	193.7671	215.2856	213.3385	245.8487	243.4493	258.5864	256.1745
EPCSRST_N_4	B36	238.6005	236.6785	170.5276	169.1081	198.9049	197.2467	219.7953	217.9613	252.3557	250.1951	266.1487	263.7870
EPCSRST_N_5	B37	237.4825	235.3846	168.6685	167.1736	196.4930	194.8098	216.5920	214.7078	247.4691	245.3085	260.5335	258.3226
SELBLK_0	B5	237.1233	235.4404	169.0783	167.8978	197.3111	195.9045	217.8828	216.1622	249.3935	247.7231	263.1205	261.4250
SELBLK_1	B6	236.3321	234.6115	167.6340	166.5163	195.1635	193.9076	215.0319	213.4243	245.1987	243.5535	257.9336	256.4140
SELBLK_2	C6	236.0335	234.4764	167.0168	165.9117	193.9780	193.0236	213.8944	212.6387	243.1914	242.1491	255.5858	254.7570
SELBLK_3	D7	235.7485	234.0783	166.1654	165.1608	193.2401	192.0095	212.7174	211.1853	241.7385	240.2818	254.1959	252.6639
MONITOR	K23	236.1935	233.5058	167.5073	166.0002	195.0747	193.3290	214.7047	212.6450	244.6961	242.5484	257.5692	255.2583
PLL_MON	L20	235.7319	233.2393	165.1337	163.5853	191.4444	189.7449	210.5164	208.6155	237.9349	235.9963	249.4789	247.6661
TOGGLE_MON	L22	235.6103	233.1104	166.1416	164.2572	192.6603	190.7257	211.8553	209.4936	240.2332	237.6454	252.1923	249.4287



Table 17. LVCMOS 25 VOL – 4649

Pin Name	Pin #	2mA		4mA		6mA		8mA		12mA		14mA	
		Pre rad	Post Rad	Pre rad	Post Rad	Pre rad	Post Rad	Pre rad	Post Rad	Pre rad	Post Rad	Pre rad	Post Rad
BIST	A10	236.2818	234.5738	167.8727	166.9810	195.6658	194.6988	215.5468	214.6928	246.5175	245.7262	259.5663	258.8881
CLK	A12	236.5330	234.6994	168.3750	167.5587	196.5450	195.6658	216.9032	216.0366	248.4767	247.6478	261.9023	261.2367
TOGGLE	A13	236.1814	234.3477	167.4457	166.6796	195.0379	194.1462	214.9942	214.1277	245.6383	244.9099	258.5490	258.1722
RESETh	A15	235.6819	234.2504	167.3056	166.4391	194.9826	194.1664	215.2381	214.4218	245.6527	244.9997	258.5117	258.1475
BURNIN_SERDES	A18	235.0289	233.4215	166.3763	165.5350	193.6264	192.7725	213.3544	212.4377	243.0030	242.2747	255.5983	255.0960
OEa	A22	236.3600	234.8280	167.9460	167.1549	195.7612	194.8822	216.2553	215.2381	247.2726	246.1927	260.4707	259.6419
OEb	A23	235.4559	233.9113	166.7280	165.7736	193.9655	192.9734	213.7437	212.6763	243.4928	242.6891	256.1634	255.3597
SETn	A24	235.9205	234.3006	167.9335	167.1172	195.9621	195.0831	216.4687	215.5520	247.6368	246.9335	260.9730	260.3326
BURNIN	A25	235.3052	233.7229	166.8535	165.9871	194.4050	193.5134	214.6730	213.5679	245.0374	244.1458	257.9592	257.3187
TID_BUF_IN	A32	236.9223	235.8297	169.5179	168.9402	198.0018	197.5120	218.6866	218.2470	250.8880	250.9759	264.9541	264.9667
TID_BUF_OUT	A33	237.1986	235.2394	168.2997	166.9935	196.1557	194.6611	216.3506	214.7305	247.2836	245.6383	260.5585	258.7374
EPCSRST_N_0	B31	236.0809	234.1593	168.2997	167.0940	196.4445	195.1258	216.9786	215.2957	248.6148	246.7812	262.3167	260.3575
EPCSRST_N_1	B32	235.5856	233.7641	167.1862	165.9551	194.5208	193.3651	214.5696	213.0496	245.2959	243.5750	258.3101	256.6644
EPCSRST_N_2	B34	237.2815	235.5354	169.1961	167.9525	197.2719	195.9152	217.8357	216.2152	249.5795	247.7706	263.2845	261.2998
EPCSRST_N_3	B35	236.2263	234.4174	167.4374	166.2440	194.7469	193.6289	214.7078	213.0873	245.0196	243.2735	257.7824	256.0363
EPCSRST_N_4	B36	237.8844	236.0755	170.4146	169.2966	199.2190	197.8623	220.2852	218.7401	253.0215	251.4764	267.3169	265.5708
EPCSRST_N_5	B37	237.0930	235.3092	168.5680	167.5002	196.5307	195.3750	216.9061	215.4866	248.2229	246.8034	261.6138	260.1692
SELBLK_0	B5	237.3368	236.1562	169.2165	168.4755	197.4743	196.5575	218.1466	217.0790	250.0214	248.9162	263.6731	262.7312
SELBLK_1	B6	236.6084	235.1892	167.8224	167.0061	195.4398	194.4853	215.4464	214.3914	245.8895	244.8722	258.8128	257.6825
SELBLK_2	C6	236.0461	235.0666	166.7028	166.2633	193.9655	193.5762	213.7688	213.2665	243.2542	243.0156	255.8620	255.7616
SELBLK_3	D7	235.6857	234.3420	166.5422	165.6631	193.6671	192.7629	212.7550	211.8634	242.3036	241.3116	254.6229	253.5429
MONITOR	K23	235.5781	233.4807	167.2435	165.9374	194.7482	193.2913	214.1772	212.4315	244.1937	242.5108	256.9790	255.1077
PLL_MON	L20	233.9569	232.0434	164.5924	163.3461	190.7394	189.4427	209.6604	208.4015	237.3181	236.1096	248.8243	247.5906
TOGGLE_MON	L22	235.1078	232.9974	165.7019	164.3075	192.3337	190.8764	211.5161	209.5564	240.2960	237.9469	252.4310	250.0316



Table 18. LVCMOS 25 VOL – 4594

Pin Name	Pin #	2mA		4mA		6mA		8mA		12mA		14mA	
		Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad
BIST	A10	238.4043	236.2316	169.5556	168.3374	197.5999	196.1431	217.7698	216.3380	249.0669	247.8236	262.3670	261.1613
CLK	A12	238.6053	236.3069	169.9072	168.6890	198.3284	197.0473	218.9880	217.6442	250.7750	249.5944	264.6025	263.5601
TOGGLE	A13	238.0652	235.8548	168.8397	167.5838	196.7334	195.2765	216.7776	215.2705	247.9492	246.4170	261.0232	259.5286
RESETn	A15	238.6581	236.6614	169.0511	167.7200	196.9039	195.5226	216.9208	215.6023	247.6619	246.4564	260.8223	259.5038
BURNIN_SERDES	A18	237.1888	235.2298	167.7326	166.4894	195.2463	193.9780	215.1251	213.7814	244.9997	243.7690	257.8838	256.5652
OEa	A22	238.2437	236.1591	169.1139	167.9209	197.0923	195.9245	217.4482	216.0418	248.6539	247.4108	261.9525	260.8349
OEb	A23	237.9172	235.8452	167.9963	166.7154	195.3468	193.9780	215.1502	213.6056	244.9369	243.5304	257.5573	256.2137
SETn	A24	237.6409	235.5312	169.0762	167.9460	197.2556	195.9621	217.9003	216.7199	249.3572	248.3400	262.8190	261.6888
BURNIN	A25	237.4525	235.3554	168.3604	167.1800	196.1379	194.7691	216.2804	215.0121	247.0466	245.4643	260.0940	258.4991
TID_BUF_IN	A32	239.0323	237.1861	170.7989	169.8444	199.4461	198.4665	220.2942	219.3271	252.9728	252.2821	267.0515	266.4110
TID_BUF_OUT	A33	239.2332	236.4828	169.9324	167.8852	198.1525	195.7538	218.5736	215.8734	250.3605	246.9947	263.7862	260.2068
EPCSRST_N_0	B31	237.8266	235.4027	169.6058	167.9229	198.1023	196.0803	218.6992	216.4636	250.8754	248.2757	264.5146	261.8395
EPCSRST_N_1	B32	236.6785	234.4802	168.2665	166.8219	196.0911	194.4454	216.2026	214.2178	247.1928	245.1075	260.4456	258.3352
EPCSRST_N_2	B34	238.6130	236.4273	170.0880	168.6182	198.4150	196.6815	218.9034	217.0694	250.9362	248.8761	264.5407	262.4052
EPCSRST_N_3	B35	238.2613	235.9625	168.8318	167.2490	196.5056	194.6967	216.3282	214.3937	246.8034	244.7055	259.5034	257.4056
EPCSRST_N_4	B36	239.1281	236.9172	171.0175	169.4850	199.8345	197.8497	220.6118	218.5014	253.2853	250.8860	267.4300	264.7166
EPCSRST_N_5	B37	238.7763	236.2891	169.3343	167.7640	197.2091	195.5635	217.3835	215.2479	248.3485	246.1250	261.2747	259.0889
SELBLK_0	B5	240.0244	238.2787	170.6105	169.4300	198.8935	197.5246	219.3271	217.7823	250.9006	249.4437	264.6653	262.8819
SELBLK_1	B6	239.0574	237.3870	169.0407	167.9103	196.8338	195.5026	216.7148	215.0068	246.8817	245.2239	259.7547	257.8583
SELBLK_2	C6	238.8716	237.1512	168.2600	167.1172	195.6482	194.3924	215.2255	213.9823	244.8239	243.3044	257.1680	255.9248
SELBLK_3	D7	237.7326	235.9619	167.7477	166.6677	195.0862	193.6671	214.1992	212.9057	243.6097	242.0650	255.9164	254.3592
MONITOR	K23	237.9769	235.4525	168.6251	166.8668	196.3181	194.4342	215.9104	213.6874	246.1655	243.6913	259.0764	256.4515
PLL_MON	L20	236.0089	233.4659	165.8764	164.3406	192.3759	190.7771	211.4480	209.5597	239.2568	237.4062	250.8385	249.0887
TOGGLE_MON	L22	237.1680	234.3918	167.2470	165.2371	194.1426	191.6930	213.4632	210.5111	242.3562	239.0523	254.6043	251.0617





Table 19. LVTTTL VOH - 4601

Pin Name	Pin #	2mA		4mA		6mA		12mA		16mA	
		Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad
BIST	A10	2.9183	2.9187	2.9093	2.9095	2.8913	2.8914	2.8735	2.8734	2.8557	2.8553
CLK	A12	2.9202	2.9204	2.9108	2.9109	2.8919	2.8919	2.8733	2.8733	2.8544	2.8542
TOGGLE	A13	2.9211	2.9212	2.9119	2.9123	2.8943	2.8943	2.8766	2.8767	2.8588	2.8586
RESETn	A15	2.9199	2.9200	2.9112	2.9112	2.8937	2.8935	2.8761	2.8760	2.8586	2.8582
BURNIN_SERDES	A18	2.9210	2.9209	2.9125	2.9126	2.8957	2.8957	2.8789	2.8789	2.8623	2.8622
OEa	A22	2.9195	2.9199	2.9107	2.9108	2.8927	2.8929	2.8747	2.8747	2.8565	2.8563
OEb	A23	2.9210	2.9211	2.9123	2.9127	2.8957	2.8955	2.8788	2.8786	2.8623	2.8618
SETn	A24	2.9201	2.9203	2.9110	2.9112	2.8928	2.8928	2.8745	2.8740	2.8562	2.8559
BURNIN	A25	2.9209	2.9209	2.9121	2.9122	2.8947	2.8946	2.8772	2.8772	2.8600	2.8596
TID_BUF_IN	A32	2.9190	2.9191	2.9090	2.9089	2.8894	2.8891	2.8701	2.8694	2.8505	2.8492
TID_BUF_OUT	A33	2.9191	2.9193	2.9097	2.9101	2.8916	2.8922	2.8735	2.8742	2.8554	2.8560
EPCSRST_N_0	B31	2.9193	2.9197	2.9098	2.9104	2.8906	2.8916	2.8720	2.8733	2.8530	2.8545
EPCSRST_N_1	B32	2.9197	2.9199	2.9105	2.9111	2.8932	2.8936	2.8757	2.8760	2.8579	2.8580
EPCSRST_N_2	B34	2.9184	2.9187	2.9086	2.9090	2.8899	2.8905	2.8710	2.8720	2.8526	2.8534
EPCSRST_N_3	B35	2.9199	2.9201	2.9109	2.9114	2.8935	2.8940	2.8760	2.8770	2.8588	2.8595
EPCSRST_N_4	B36	2.9179	2.9181	2.9080	2.9085	2.8888	2.8895	2.8693	2.8700	2.8499	2.8504
EPCSRST_N_5	B37	2.9187	2.9190	2.9099	2.9101	2.8919	2.8925	2.8739	2.8746	2.8562	2.8569
SELBLK_0	B5	2.9177	2.9181	2.9081	2.9084	2.8893	2.8896	2.8704	2.8711	2.8515	2.8521
SELBLK_1	B6	2.9183	2.9184	2.9094	2.9098	2.8918	2.8923	2.8745	2.8749	2.8571	2.8576
SELBLK_2	C6	2.9182	2.9186	2.9097	2.9098	2.8929	2.8932	2.8764	2.8767	2.8599	2.8598
SELBLK_3	D7	2.9182	2.9185	2.9101	2.9103	2.8943	2.8946	2.8779	2.8783	2.8612	2.8616
MONITOR	K23	2.9211	2.9215	2.9123	2.9126	2.8951	2.8956	2.8779	2.8783	2.8606	2.8611
PLL_MON	L20	2.9210	2.9215	2.9138	2.9143	2.8996	2.8998	2.8852	2.8854	2.8707	2.8711
TOGGLE_MON	L22	2.9218	2.9221	2.9135	2.9138	2.8980	2.8987	2.8826	2.8835	2.8673	2.8683



Table 20. LVTTTL VOH - 4649

Pin Name	Pin #	2mA		4mA		6mA		12mA		16mA	
		Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad
BIST	A10	2.9189	2.9189	2.9097	2.9095	2.8918	2.8915	2.8739	2.8735	2.8562	2.8554
CLK	A12	2.9211	2.9209	2.9116	2.9115	2.8930	2.8926	2.8745	2.8737	2.8560	2.8550
TOGGLE	A13	2.9216	2.9216	2.9123	2.9121	2.8947	2.8943	2.8773	2.8765	2.8597	2.8584
RESETn	A15	2.9215	2.9214	2.9125	2.9124	2.8949	2.8945	2.8772	2.8765	2.8598	2.8587
BURNIN_SERDES	A18	2.9220	2.9221	2.9134	2.9131	2.8963	2.8958	2.8796	2.8791	2.8630	2.8621
OEa	A22	2.9210	2.9211	2.9119	2.9117	2.8937	2.8934	2.8755	2.8749	2.8571	2.8565
OEb	A23	2.9221	2.9220	2.9132	2.9132	2.8961	2.8958	2.8795	2.8787	2.8625	2.8619
SETn	A24	2.9213	2.9212	2.9119	2.9121	2.8937	2.8931	2.8750	2.8747	2.8570	2.8560
BURNIN	A25	2.9220	2.9217	2.9129	2.9128	2.8956	2.8951	2.8780	2.8773	2.8604	2.8598
TID_BUF_IN	A32	2.9194	2.9192	2.9095	2.9089	2.8897	2.8889	2.8704	2.8690	2.8510	2.8491
TID_BUF_OUT	A33	2.9195	2.9194	2.9100	2.9102	2.8920	2.8921	2.8740	2.8742	2.8558	2.8559
EPCSRST_N_0	B31	2.9202	2.9204	2.9104	2.9108	2.8917	2.8918	2.8728	2.8733	2.8540	2.8545
EPCSRST_N_1	B32	2.9200	2.9201	2.9114	2.9113	2.8936	2.8938	2.8760	2.8762	2.8583	2.8584
EPCSRST_N_2	B34	2.9189	2.9188	2.9092	2.9095	2.8905	2.8906	2.8717	2.8721	2.8527	2.8533
EPCSRST_N_3	B35	2.9196	2.9199	2.9112	2.9114	2.8940	2.8942	2.8765	2.8770	2.8595	2.8597
EPCSRST_N_4	B36	2.9187	2.9186	2.9084	2.9087	2.8885	2.8885	2.8685	2.8689	2.8485	2.8486
EPCSRST_N_5	B37	2.9190	2.9190	2.9100	2.9101	2.8918	2.8917	2.8735	2.8736	2.8550	2.8550
SELBLK_0	B5	2.9173	2.9172	2.9078	2.9078	2.8889	2.8889	2.8699	2.8698	2.8507	2.8507
SELBLK_1	B6	2.9182	2.9180	2.9090	2.9089	2.8915	2.8914	2.8739	2.8741	2.8566	2.8564
SELBLK_2	C6	2.9183	2.9180	2.9099	2.9097	2.8932	2.8928	2.8768	2.8759	2.8600	2.8590
SELBLK_3	D7	2.9187	2.9185	2.9104	2.9103	2.8937	2.8937	2.8773	2.8775	2.8607	2.8605
MONITOR	K23	2.9220	2.9217	2.9131	2.9131	2.8958	2.8960	2.8787	2.8787	2.8614	2.8614
PLL_MON	L20	2.9225	2.9225	2.9150	2.9151	2.9007	2.9005	2.8858	2.8858	2.8714	2.8712
TOGGLE_MON	L22	2.9219	2.9223	2.9140	2.9146	2.8982	2.8990	2.8826	2.8835	2.8669	2.8677



Table 21. LVTTTL VOH - 4594

Pin Name	Pin #	2mA		4mA		6mA		12mA		16mA	
		Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad
BIST	A10	2.9177	2.9181	2.9083	2.9084	2.8901	2.8901	2.8720	2.8718	2.8538	2.8535
CLK	A12	2.9196	2.9197	2.9099	2.9102	2.8910	2.8910	2.8722	2.8721	2.8533	2.8527
TOGGLE	A13	2.9199	2.9205	2.9112	2.9115	2.8930	2.8931	2.8753	2.8754	2.8571	2.8571
RESETn	A15	2.9199	2.9200	2.9107	2.9108	2.8933	2.8931	2.8755	2.8754	2.8580	2.8577
BURNIN_SERDES	A18	2.9209	2.9211	2.9122	2.9124	2.8950	2.8950	2.8782	2.8781	2.8611	2.8610
OEa	A22	2.9201	2.9205	2.9109	2.9112	2.8928	2.8929	2.8743	2.8746	2.8560	2.8558
OEb	A23	2.9203	2.9207	2.9120	2.9123	2.8953	2.8953	2.8783	2.8782	2.8615	2.8613
SETn	A24	2.9202	2.9207	2.9107	2.9111	2.8924	2.8926	2.8737	2.8736	2.8555	2.8550
BURNIN	A25	2.9203	2.9207	2.9113	2.9117	2.8936	2.8939	2.8759	2.8761	2.8585	2.8587
TID_BUF_IN	A32	2.9181	2.9183	2.9081	2.9078	2.8883	2.8880	2.8686	2.8681	2.8489	2.8480
TID_BUF_OUT	A33	2.9177	2.9184	2.9086	2.9090	2.8897	2.8910	2.8711	2.8728	2.8522	2.8544
EPCSRST_N_0	B31	2.9187	2.9193	2.9090	2.9098	2.8898	2.8908	2.8708	2.8720	2.8516	2.8531
EPCSRST_N_1	B32	2.9195	2.9196	2.9101	2.9107	2.8923	2.8928	2.8742	2.8747	2.8563	2.8568
EPCSRST_N_2	B34	2.9179	2.9184	2.9084	2.9088	2.8893	2.8900	2.8703	2.8713	2.8517	2.8523
EPCSRST_N_3	B35	2.9185	2.9189	2.9099	2.9101	2.8923	2.8928	2.8747	2.8757	2.8576	2.8584
EPCSRST_N_4	B36	2.9177	2.9185	2.9080	2.9085	2.8879	2.8889	2.8683	2.8695	2.8487	2.8499
EPCSRST_N_5	B37	2.9182	2.9183	2.9091	2.9096	2.8915	2.8920	2.8735	2.8741	2.8556	2.8563
SELBLK_0	B5	2.9157	2.9160	2.9063	2.9068	2.8880	2.8884	2.8693	2.8701	2.8505	2.8512
SELBLK_1	B6	2.9165	2.9167	2.9075	2.9081	2.8907	2.8912	2.8732	2.8741	2.8559	2.8567
SELBLK_2	C6	2.9165	2.9170	2.9084	2.9085	2.8919	2.8922	2.8753	2.8758	2.8590	2.8594
SELBLK_3	D7	2.9173	2.9177	2.9089	2.9092	2.8927	2.8932	2.8763	2.8768	2.8598	2.8603
MONITOR	K23	2.9197	2.9200	2.9115	2.9120	2.8943	2.8948	2.8770	2.8778	2.8595	2.8603
PLL_MON	L20	2.9214	2.9217	2.9142	2.9143	2.8993	2.8993	2.8843	2.8846	2.8699	2.8700
TOGGLE_MON	L22	2.9208	2.9214	2.9128	2.9132	2.8969	2.8980	2.8807	2.8828	2.8650	2.8671



Table 22. LVTTTL VOL - 4601

Pin Name	Pin #	2mA		4mA		6mA		12mA		16mA	
		Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad
BIST	A10	216.3663	214.4603	224.6154	222.5531	242.0509	240.5823	259.7052	258.4865	277.7644	276.6843
CLK	A12	217.0225	215.0227	225.6465	223.5217	243.9257	242.3946	262.3299	261.1425	281.3563	279.9748
TOGGLE	A13	216.2413	214.3040	224.0842	222.2094	241.5509	239.9261	258.8928	257.6741	276.8350	275.6042
RESETn	A15	216.8116	215.2807	225.1225	223.9352	241.7755	240.7757	259.1158	258.1472	277.2477	276.2431
BURNIN_SERDES	A18	215.5619	213.9372	223.7790	221.9356	239.4947	238.1199	255.8977	254.8666	273.3171	272.1242
OEa	A22	217.2803	215.7494	225.8411	224.2164	242.5566	240.9944	260.4280	258.9283	278.8300	277.5365
OEb	A23	215.8431	214.2496	224.0915	222.3106	239.8383	238.5573	256.3351	255.1478	273.4930	272.5260
SETn	A24	216.4055	214.6871	225.4662	223.7165	242.7440	241.4005	261.0217	259.5844	279.4453	278.5034
BURNIN	A25	215.9368	213.9685	224.2789	222.5918	240.4632	239.2135	257.9598	256.4913	275.9040	274.6106
TID_BUF_IN	A32	217.0537	215.6476	226.2089	224.8028	245.2068	244.0194	264.3296	263.9547	284.0816	283.6546
TID_BUF_OUT	A33	216.7725	214.5227	225.3028	222.8968	243.0195	240.6760	260.6738	258.4553	278.9073	276.5210
EPCSRST_N_0	B31	216.4913	214.4290	224.9591	222.6781	243.7382	241.3947	262.2361	259.7989	281.1679	278.4426
EPCSRST_N_1	B32	215.3459	213.8460	223.5022	221.2209	240.8458	239.2520	258.1582	256.5332	276.4620	274.7159
EPCSRST_N_2	B34	217.0334	215.3147	225.5021	223.5334	244.2520	242.0645	262.4394	260.4082	281.6877	279.2256
EPCSRST_N_3	B35	216.1897	214.2522	223.9084	221.5647	241.0958	239.0958	258.0644	256.1895	276.0600	273.7737
EPCSRST_N_4	B36	217.7522	216.3147	226.7834	224.3772	245.5645	244.1895	265.0956	263.0019	284.7905	282.6299
EPCSRST_N_5	B37	216.6897	215.0647	224.7209	222.5959	242.3458	240.6270	260.2207	258.2519	278.3714	276.1730
SELBLK_0	B5	216.5850	215.4289	225.5840	223.8654	243.9257	242.4883	262.3611	261.0488	281.3688	279.6733
SELBLK_1	B6	215.8351	214.2103	223.9279	222.0219	241.1447	239.6762	258.3615	256.9242	275.5289	274.0343
SELBLK_2	C6	215.3744	214.0934	223.7478	222.4043	239.3697	238.5261	255.9289	254.8041	272.9530	271.9484
SELBLK_3	D7	215.1626	213.7878	222.5990	220.9430	238.5652	237.2217	254.7815	253.2817	271.1616	269.8430
MONITOR	K23	215.6528	213.4339	223.2784	221.0282	240.7798	239.0297	257.8437	255.8123	274.9512	272.6277
PLL_MON	L20	215.0740	213.0423	222.3883	220.3253	236.0478	234.4224	250.5199	248.8008	265.5674	263.7295
TOGGLE_MON	L22	214.9117	212.6925	222.7258	220.2253	237.5726	235.1346	252.6069	250.1689	268.7116	265.9102



Table 23. LVTTTL VOL - 4649

Pin Name	Pin #	2mA		4mA		6mA		12mA		16mA	
		Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad
BIST	A10	215.8976	214.7102	224.1779	222.7093	241.8322	241.0198	259.2990	258.8928	277.3499	276.8476
CLK	A12	216.3350	214.6477	224.7403	223.5217	243.1758	242.1134	261.5487	261.0175	280.0627	279.6106
TOGGLE	A13	215.9288	214.3353	223.9279	222.5531	241.1760	240.3948	258.5490	258.0179	276.3326	276.0815
RESETn	A15	215.2807	214.3121	224.0290	222.9042	240.8069	240.1508	258.3347	257.7723	276.3561	275.9291
BURNIN_SERDES	A18	214.7496	213.4061	223.0292	222.0919	239.1510	238.5261	255.5852	255.1166	272.9153	272.5135
OEa	A22	215.9368	214.7183	224.9663	223.5916	242.0254	241.1818	259.9281	259.1158	278.5411	277.8755
OEb	A23	214.9370	213.7498	223.4353	222.0919	239.4634	238.5886	256.1789	255.2415	273.3674	272.9530
SETn	A24	215.6244	214.1559	224.8101	223.2166	242.0879	241.3380	260.3030	259.7719	279.1439	278.7546
BURNIN	A25	214.9058	213.6873	223.6853	222.5293	240.1195	239.2447	257.6161	256.8350	275.7156	275.0752
TID_BUF_IN	A32	216.4600	215.6789	225.7402	224.7403	244.8631	244.6131	263.9547	264.1734	283.5541	283.9685
TID_BUF_OUT	A33	216.8350	214.8352	225.0528	223.0843	242.3321	240.7698	260.3301	258.7365	278.4677	276.6718
EPCSRST_N_0	B31	215.7413	214.2728	224.3654	223.0530	242.9883	241.4572	261.6424	259.9864	280.5148	278.7063
EPCSRST_N_1	B32	215.1272	213.8147	223.0959	221.2522	240.3770	238.7521	257.6894	256.5645	276.1605	274.5526
EPCSRST_N_2	B34	216.5647	215.1897	225.4396	223.1272	244.0020	242.4395	262.3456	260.7519	281.8259	279.9542
EPCSRST_N_3	B35	215.7209	214.3147	223.6584	221.5334	240.4708	239.1270	257.5332	256.3457	275.4068	273.6732
EPCSRST_N_4	B36	217.5022	215.7834	226.5021	224.4084	246.5020	244.8458	265.8144	264.3769	286.2979	284.5895
EPCSRST_N_5	B37	216.6584	215.0022	224.5959	222.9397	242.9395	241.6583	260.9707	259.6894	279.8034	278.3965
SELBLK_0	B5	217.0225	216.1788	225.6465	224.4591	244.2694	243.5195	263.0485	262.2049	282.2982	281.3186
SELBLK_1	B6	216.1788	215.3039	224.3966	223.2405	241.6759	240.7698	258.8615	258.2053	276.5210	275.6670
SELBLK_2	C6	215.5307	214.9683	223.6540	223.0292	239.4322	239.0573	256.0851	256.0226	273.2041	273.2418
SELBLK_3	D7	215.2876	214.3190	222.5990	221.0367	239.0027	238.3778	255.5314	254.5316	271.8774	270.9230
MONITOR	K23	214.9965	213.2776	222.9034	220.6220	240.4986	238.7172	257.6562	255.9061	274.5744	272.6654
PLL_MON	L20	213.8550	212.1984	221.3568	219.7314	235.5476	234.2348	249.9886	248.8008	265.1772	263.9057
TOGGLE_MON	L22	214.9117	213.0676	222.3195	220.3503	237.5726	235.4784	253.0132	250.9503	269.1261	266.7770



Table 24. LVTTTL VOL - 4594

Pin Name	Pin #	2mA		4mA		6mA		12mA		16mA	
		Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad	Pre Rad	Post Rad
BIST	A10	217.5849	216.1476	225.7402	224.0217	243.9257	242.4571	261.8924	260.7363	280.1506	279.1710
CLK	A12	217.9599	216.2413	226.1152	224.6778	245.1755	243.6132	263.8922	262.8298	282.9136	282.0093
TOGGLE	A13	217.3974	215.6476	225.2403	223.6780	242.8633	241.3635	260.7675	259.5802	278.8193	277.5886
RESETn	A15	217.7802	216.1243	226.2160	224.6226	242.9940	241.4943	260.3343	259.2095	278.3904	277.4612
BURNIN_SERDES	A18	216.3430	214.8120	224.4351	223.1541	240.6819	239.6821	257.7098	256.3663	275.0375	273.9827
OEa	A22	217.3740	215.6556	226.1848	224.5289	243.4626	241.8067	261.1466	259.9281	279.7592	278.9555
OEb	A23	216.7804	215.4369	224.7476	223.1541	240.7444	239.4634	257.5536	256.4288	274.7613	273.7315
SETn	A24	216.4992	215.2182	225.7786	224.2789	243.6501	242.1191	261.9590	260.9592	280.7387	279.9852
BURNIN	A25	216.5305	215.0932	225.4349	223.7165	242.0879	240.7757	259.6469	258.0847	277.5867	276.3184
TID_BUF_IN	A32	218.2723	216.7100	227.3650	225.9590	246.5504	245.4255	265.7982	265.3920	285.6138	285.4756
TID_BUF_OUT	A33	218.4910	216.0851	226.5526	223.8967	244.7693	242.0196	263.1423	260.1426	281.8084	278.2667
EPCSRST_N_0	B31	216.9600	215.1164	225.8965	223.6467	244.7068	242.6446	263.8297	261.3300	282.8257	280.1757
EPCSRST_N_1	B32	216.0647	214.1272	223.8459	221.5959	242.0333	240.0645	259.6582	257.9394	278.1453	276.1982
EPCSRST_N_2	B34	217.4709	215.9709	225.8771	224.0022	244.7208	243.1895	263.6269	261.8144	282.9565	280.8838
EPCSRST_N_3	B35	217.4709	215.3459	224.6584	222.4397	242.4395	240.2208	259.8144	257.6894	277.1654	274.9922
EPCSRST_N_4	B36	218.0647	216.2522	227.0334	224.6896	246.7832	244.7520	266.0956	263.5956	286.1472	283.5092
EPCSRST_N_5	B37	217.8459	215.8772	225.3459	223.0334	243.2208	241.4395	261.0332	259.0957	279.1125	277.1152
SELBLK_0	B5	218.9597	217.6161	227.3650	225.9902	245.6442	244.3006	264.0484	262.5173	282.8633	281.1930
SELBLK_1	B6	218.0536	216.7725	225.8027	224.3029	243.0508	241.6134	259.8301	258.4865	277.2495	275.5414
SELBLK_2	C6	217.7802	216.3430	225.5599	224.4664	241.3693	239.9946	257.6473	256.2726	274.2715	273.0534
SELBLK_3	D7	216.7561	215.5375	224.3174	222.5677	240.6274	239.0652	256.8124	255.3439	272.9448	271.5006
MONITOR	K23	217.3717	215.1840	224.6223	222.0596	242.4987	239.9360	259.3751	257.1249	276.4457	273.8459
PLL_MON	L20	215.5742	213.3549	223.1384	220.9817	237.3918	235.5476	251.8015	250.0511	266.9270	265.3157
TOGGLE_MON	L22	216.3808	214.0678	224.0073	221.4443	239.3542	236.6662	254.8886	251.7942	271.2240	267.6312

### E. Propagation Delay

Table 25 lists pre-irradiation and post irradiation propagation measurements. It shows that the change due to radiation on each DUT is not significant. Note fig 10 exhibits some noise which can be disregarded. The radiation environment is subject to higher noise which occasionally impacts measurements made by testing equipment. The radiation effect of the propagation delay measured on this device is still negligible and comparable with the other devices.

Table 25. Pre-irradiation and Post irradiation Propagation Delay

DUT	Total Dose	Pre-Irradiation (µs)	Post-Irradiation (µs)	Change Degradation (%)
4594	125 krad	0.452	0.451	-0.292
4649	125 krad	0.449	0.445	-0.900
4601	125 krad	0.440	0.439	-0.173

The following figures also show the propagation delay measured during irradiation of the part as a function of TID.

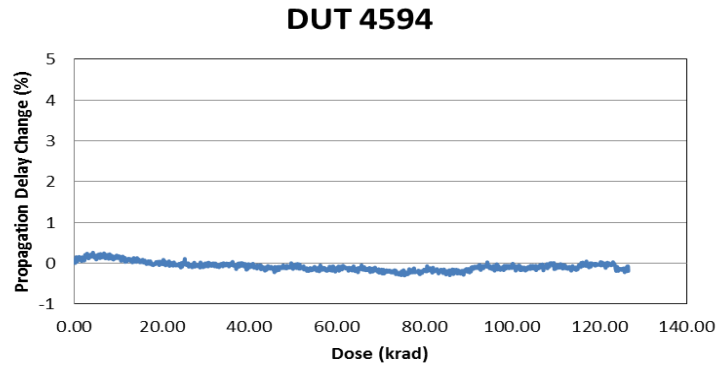


Fig. 9. DUT 4594 propagation delay degradation versus TID

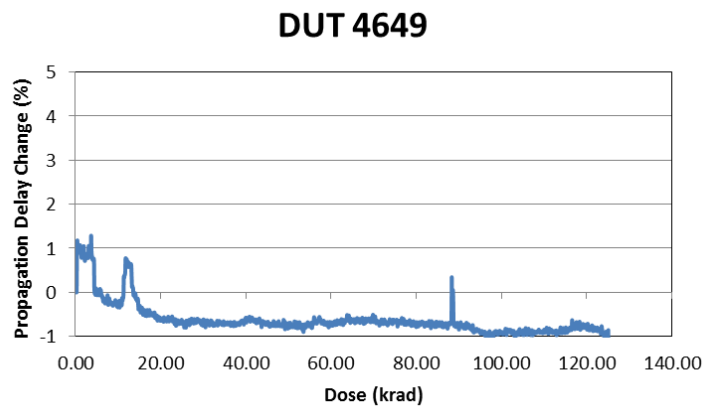


Fig. 10. DUT 4649 propagation delay degradation versus TID

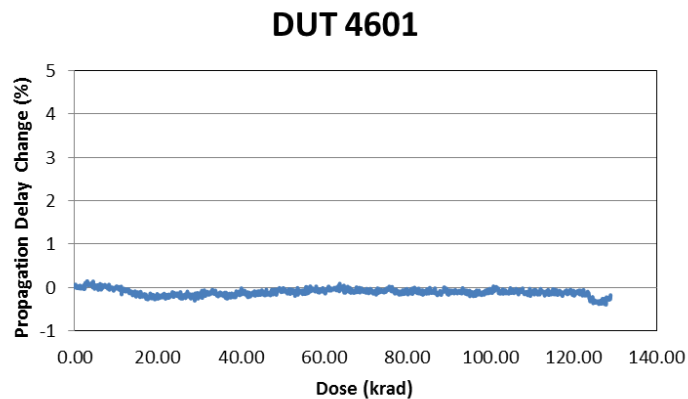


Fig. 11. DUT 4601 propagation delay degradation versus TID

## F. Transition Time

Figures show the pre-irradiation and post annealing transitions edges. In each case the radiation induced transition degradation is not observable.

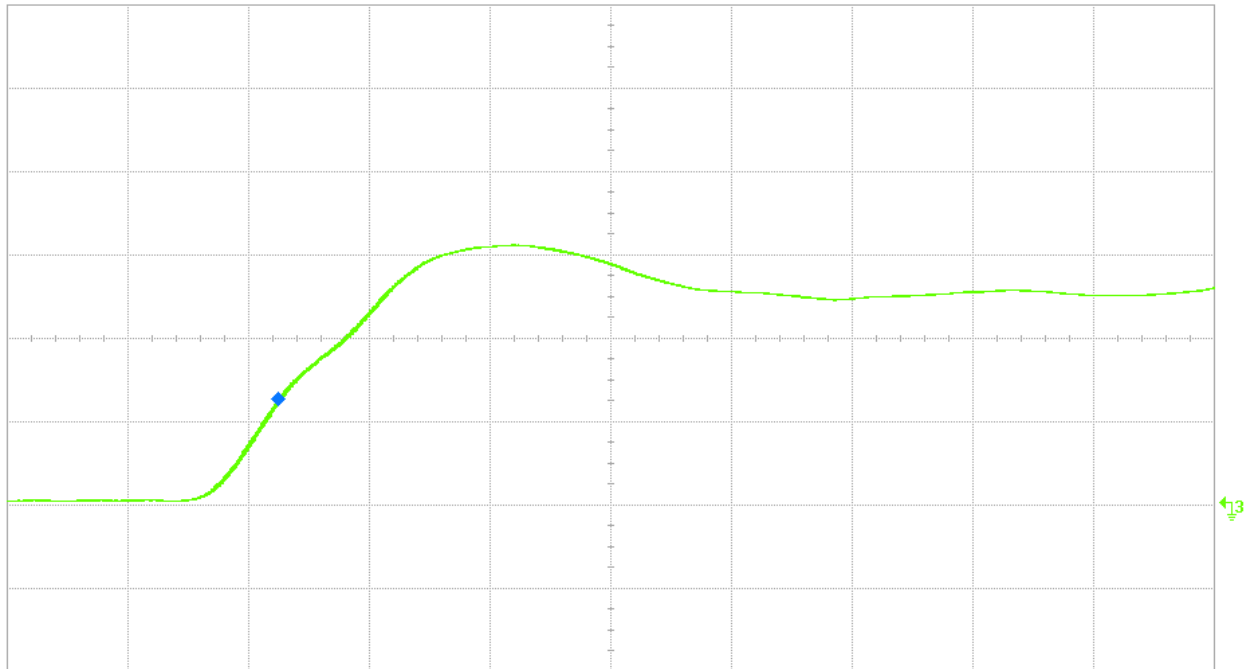


Figure 12a DUT 4594 pre-irradiation rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

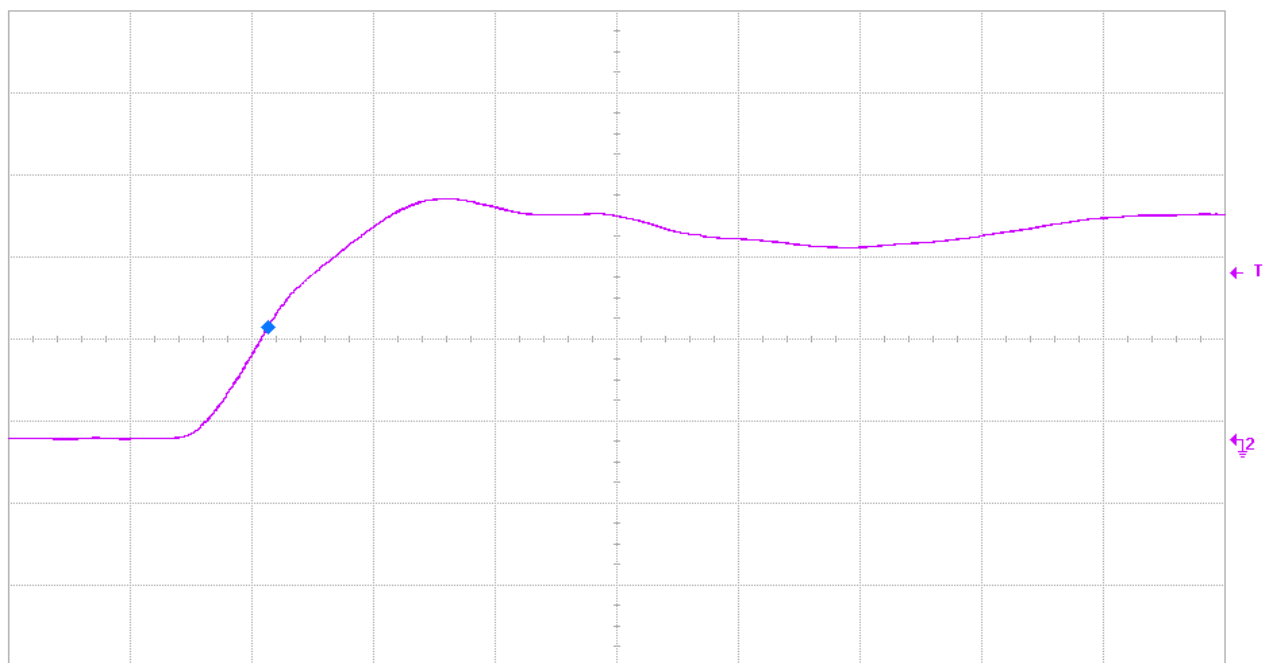


Figure 12b DUT 4594 post-annealing rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div



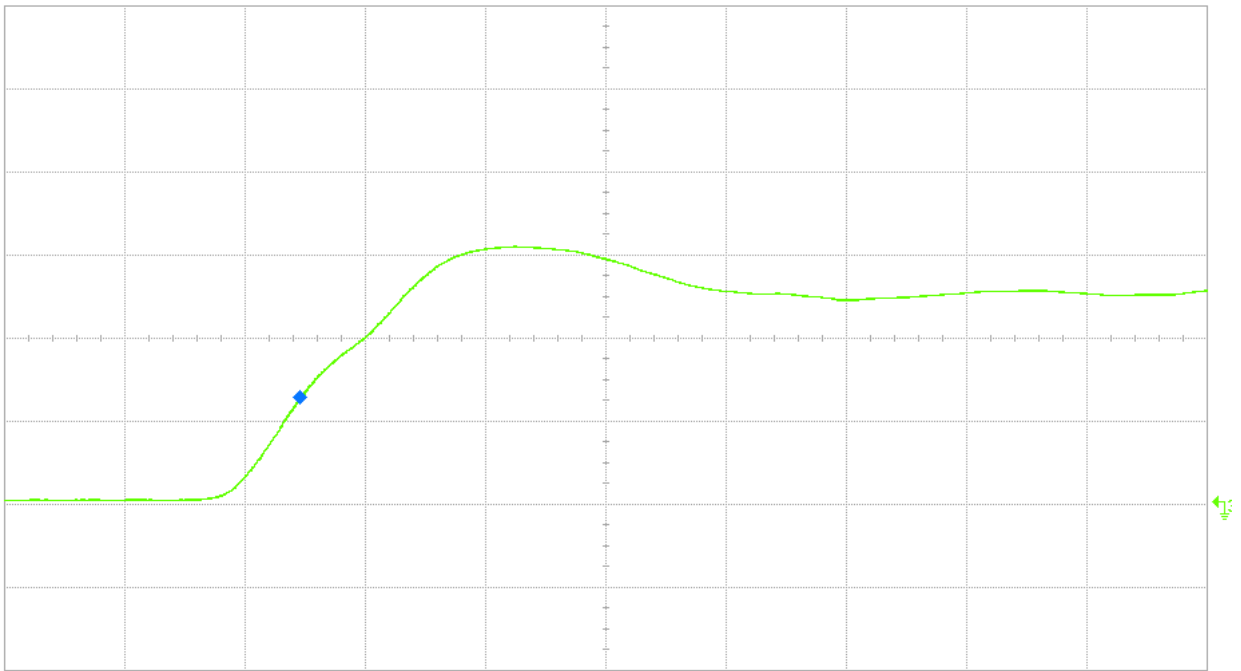


Figure 13a DUT 4601 pre-irradiation rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

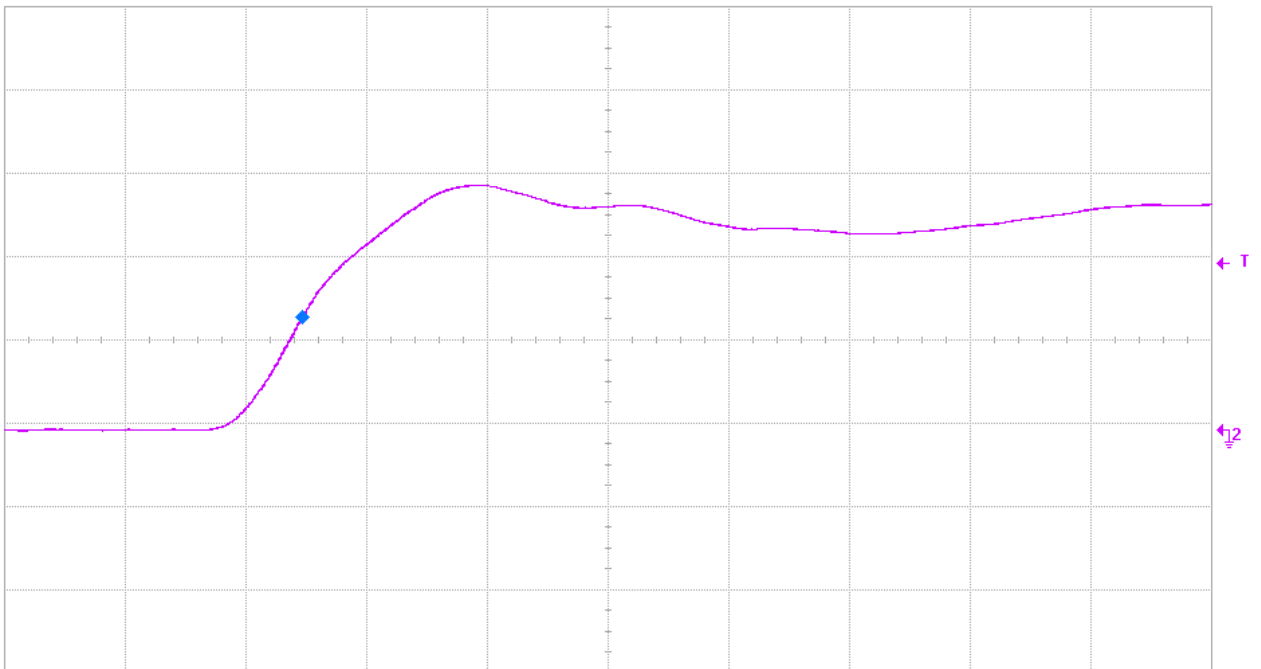


Figure 13b DUT 4601 post-annealing rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

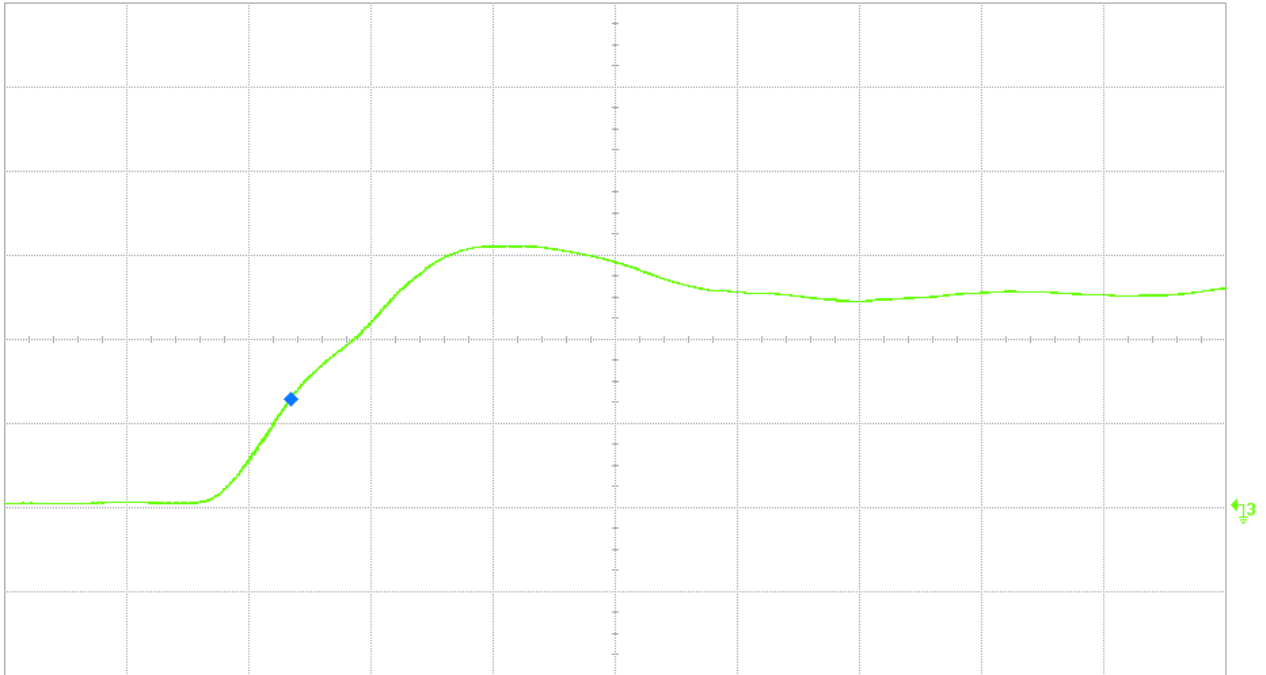


Figure 14a DUT 4649 pre-irradiation rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

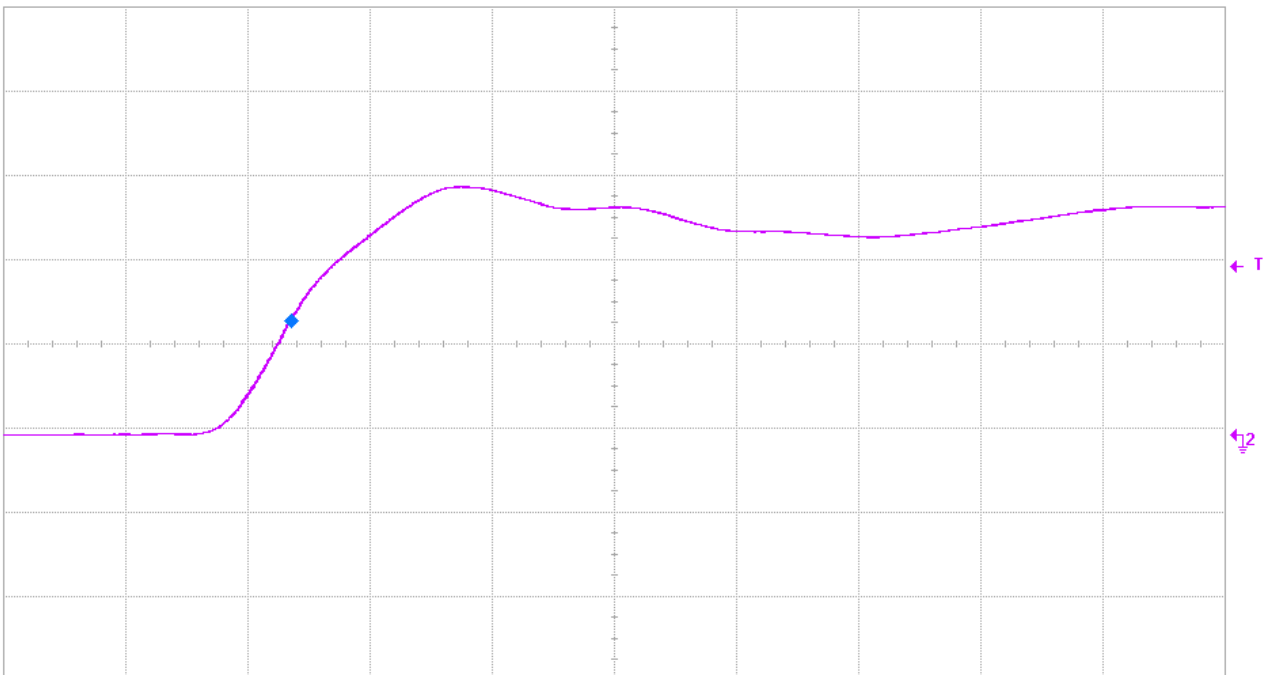


Figure 14b DUT 4649 post-annealing rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

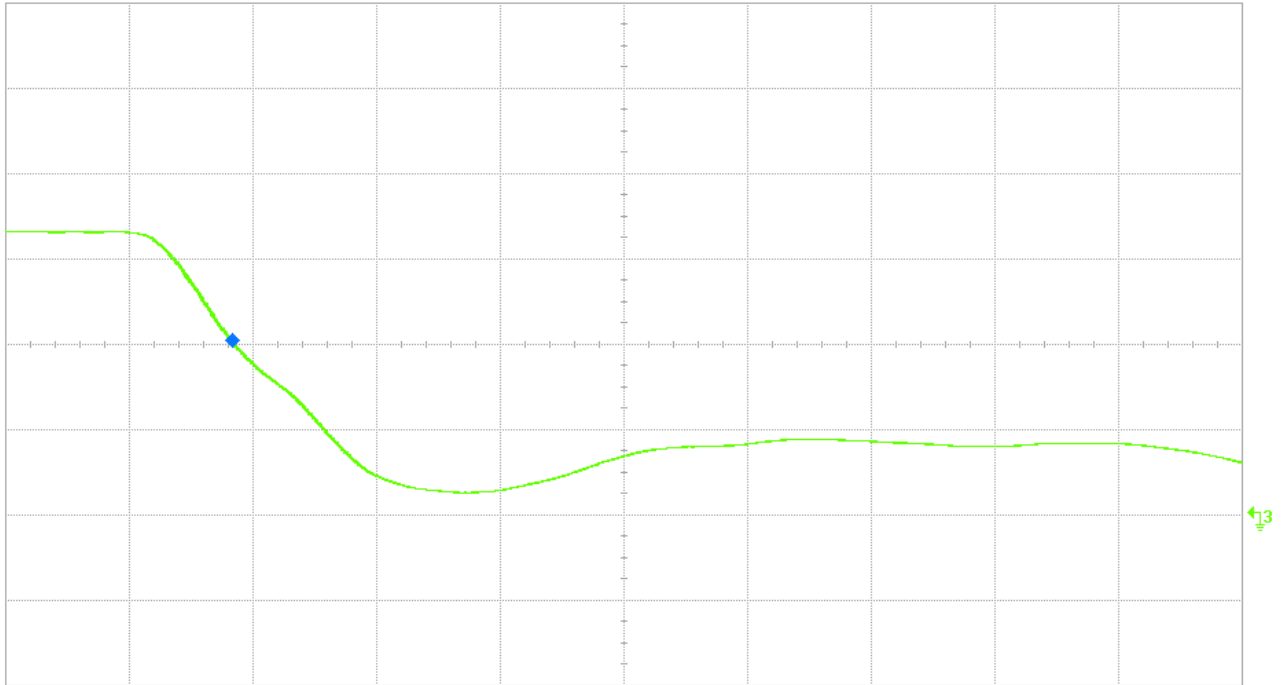


Figure 15a DUT 4594 pre-irradiation Falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

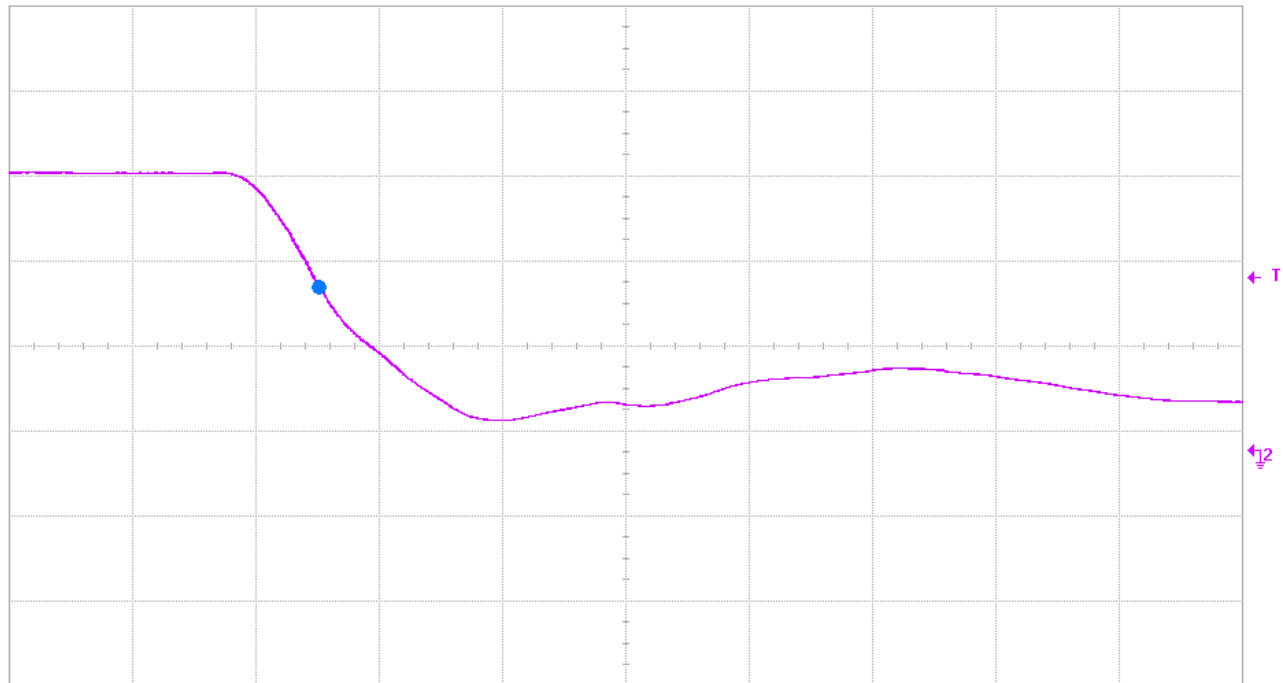


Figure 15b DUT 4594 post-annealing Falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

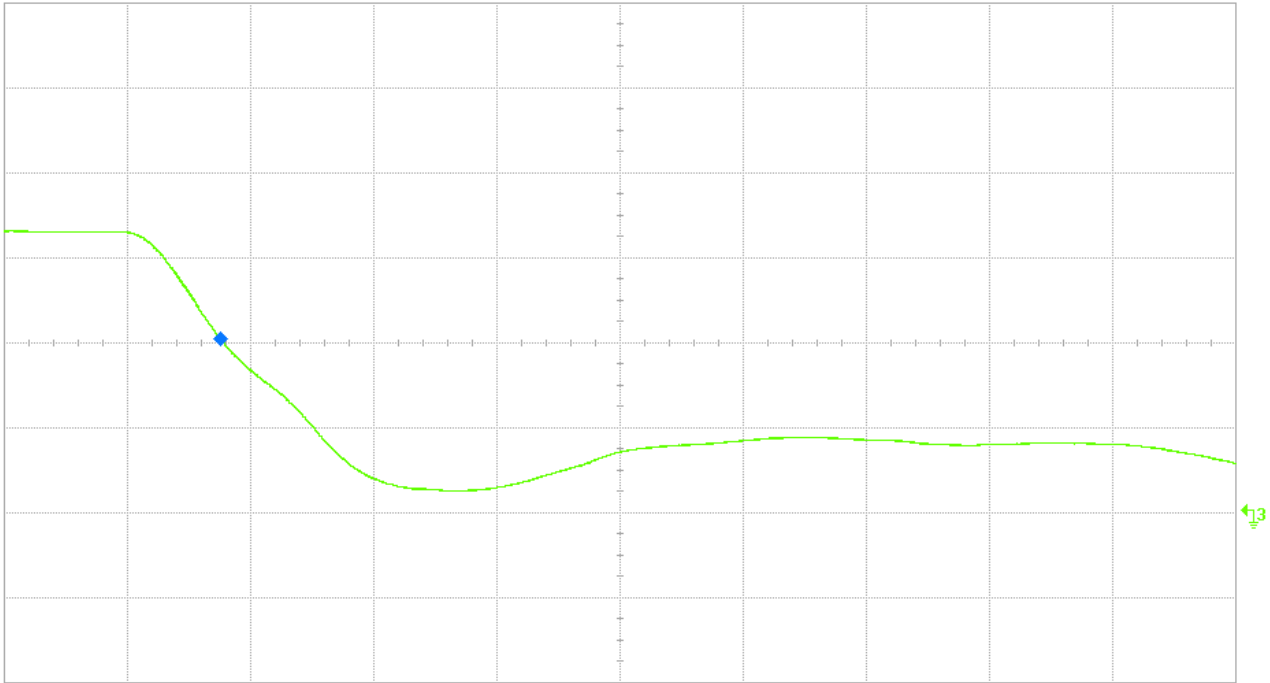


Figure 16a DUT 4601 pre-irradiation Falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

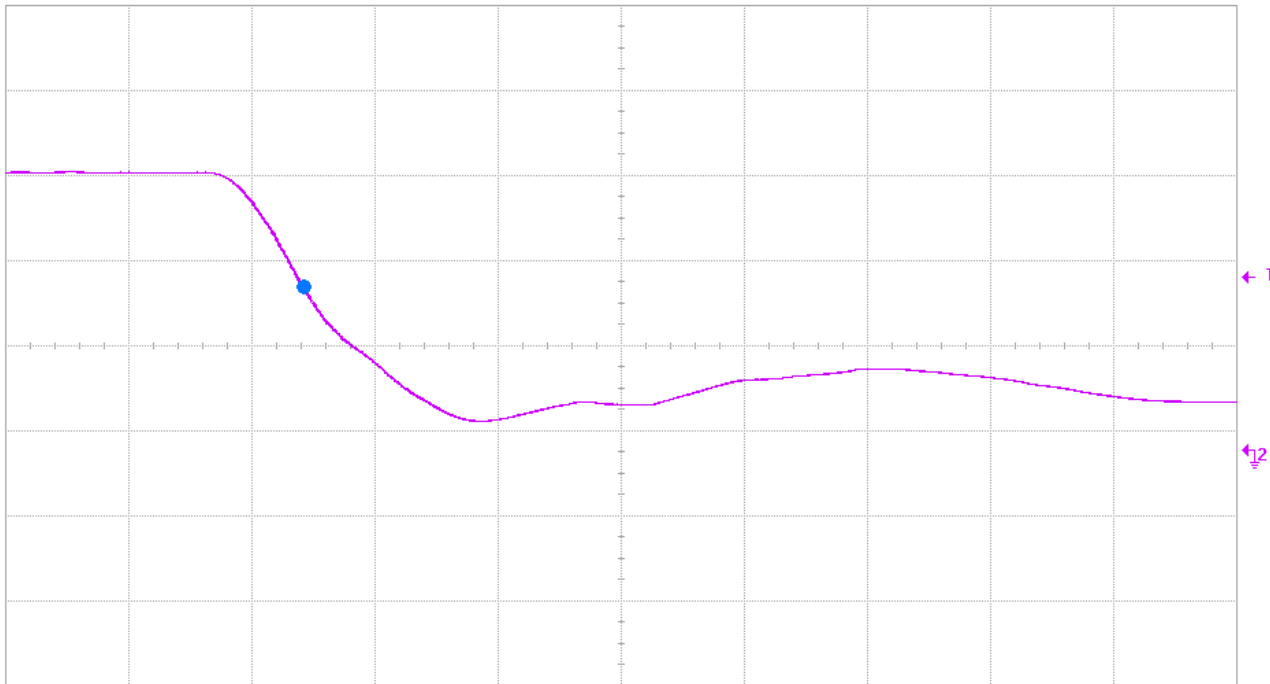


Figure 16b DUT 4601 post-annealing Falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

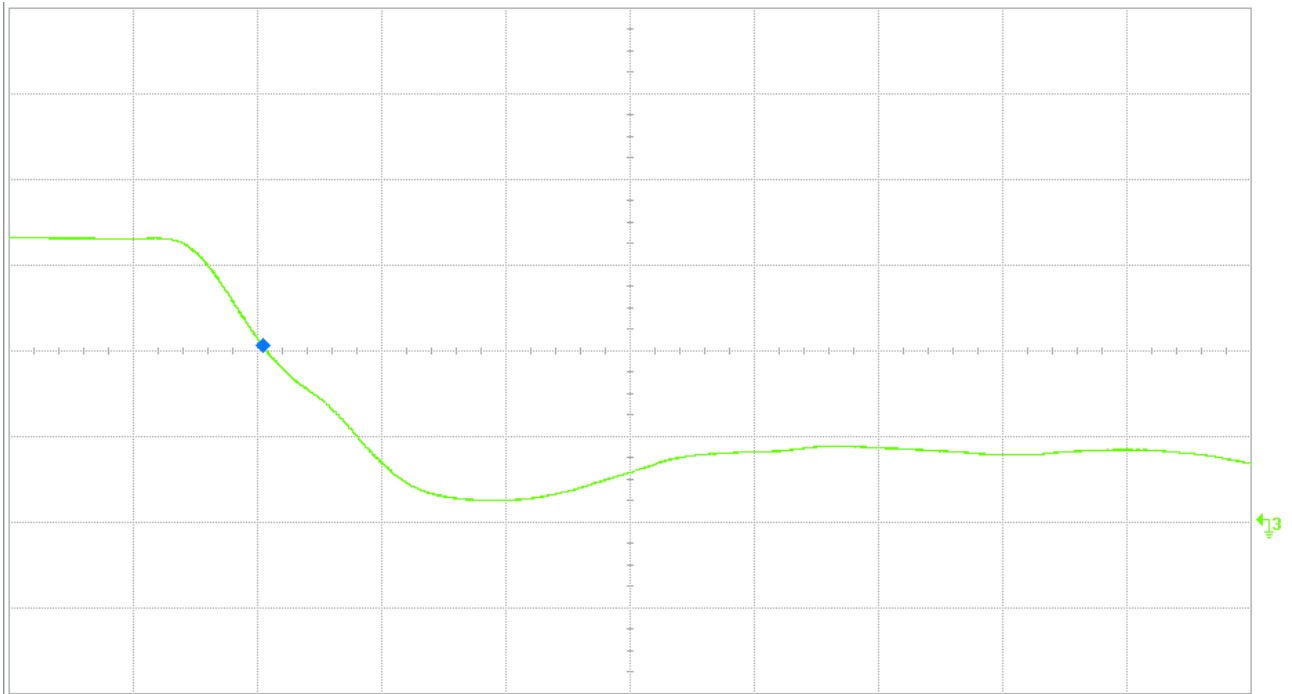


Figure 17a DUT 4649 pre-irradiation Falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

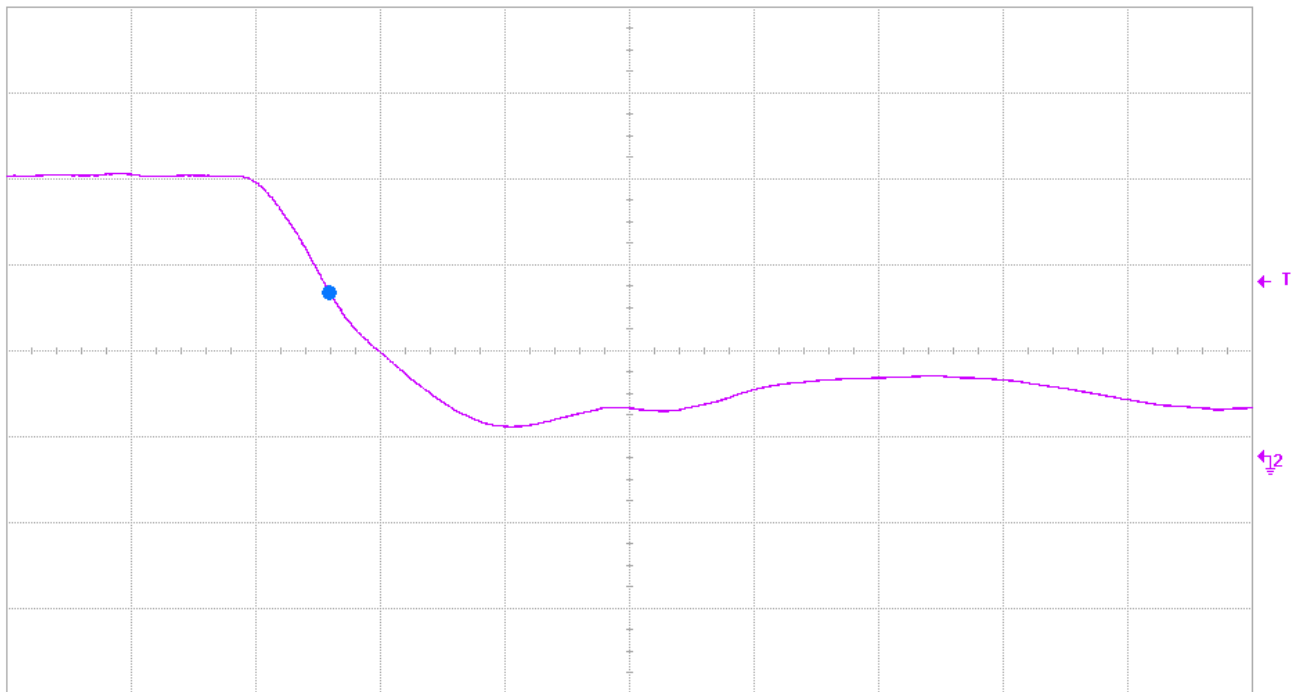


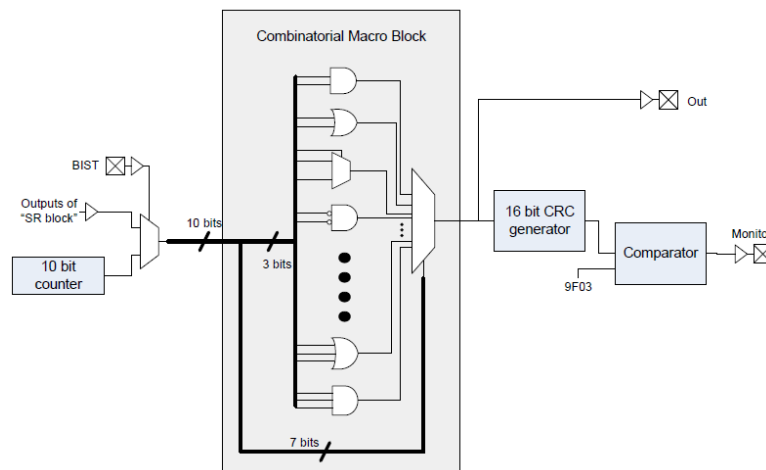
Figure 17b DUT 4649 post-annealing Falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

## Appendix A

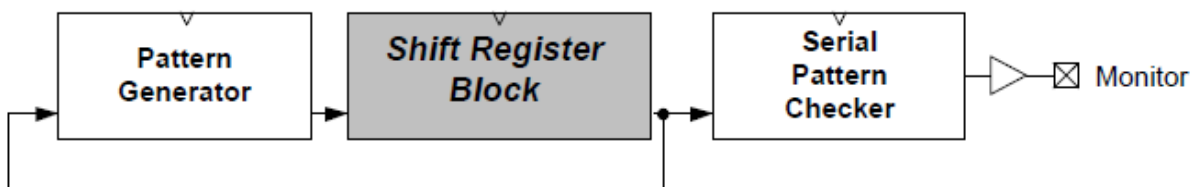
High level block diagrams of blocks used to perform fabric functional coverage pre and post irradiation

<b>Block</b>	<b>Coverage</b>
Combo Block	combinatorial macros available in the RTG4 library
Register Block	sequential macros available in the RTG4 library
UPROM	
Embedded SRAM Blocks	full toggle coverage on 209 fabric LSRAM & 210 uRAM blocks using dual port/ two port configurations (x18 width)
Shift Register Block	core utilization
IO Block	IO utilization
Math Block	full toggle coverage on 462 fabric math blocks with maximum width configuration

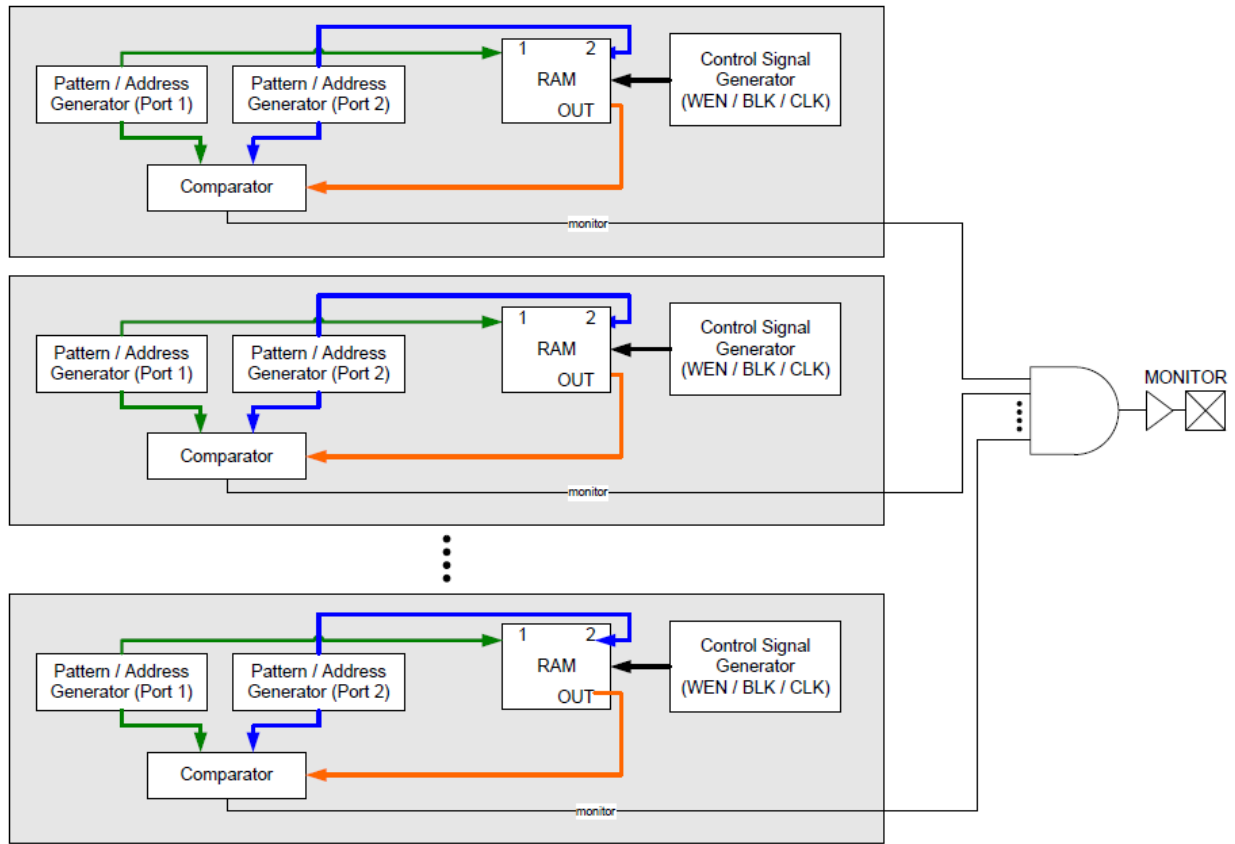
### Combo Block



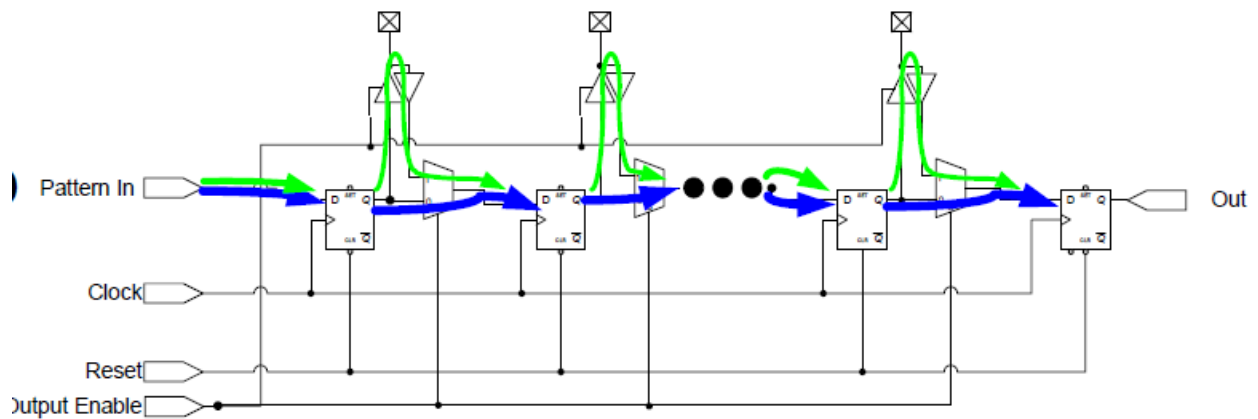
### Shift Register Block



### Embedded Ram Blocks



### IO Block



Math Block

